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THE GRAMOPHONE: ETCHING THE HUMAN VOICE.

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[*A paper read at the Stated Meeting of the* FRANKLIN INSTITUTE, *May 16, 1888.*]

JOS. M. WILSON, President, in the chair.

THE PRESIDENT introduced Mr. BRELINER, who spoke as follows:

MEMBERS OF THE FRANKLIN INSTITUTE, LADIES AND GENTLEMEN:—The last year in the first century of the history of the United States was a remarkable one in the history of science.

There appeared about that period something in the drift of scientific discussions, which, even to the mind of an observant amateur, foretold the coming of important events.

The dispute of Religion *versus* Science was once more at its height; prominent daily papers commenced to issue weekly discussions on scientific topics; series of scientific books in attractive popular form were eagerly bought by the cultured classes; popular lectures on scientific subjects were sure of commanding

enthusiastic audiences; the great works on evolution had just commenced to take root outside of the small circle of logical minds from which they had emanated, and which had fostered them. Scientific periodicals were expectantly scanned for new information, and the minds of both professionals and amateurs were on the *qui vive*.

Add to this the general excitement prevailing on account of the forthcoming centennial celebration with its crowning event, so dear to this nation of inventors, the world's exhibition, and even those who did not at the time experience the effects of an atmosphere pregnant with scientific ozone, can, in their minds, conjure up the pulsating, swaying, and turbulent sea of scientific research of that period. Science evidently was in labor.

The year 1876 came, and when the jubilee was at its very height, and when this great City of Philadelphia was one surging mass of patriots filling the air with the sounds of millions of shouts, a still small voice, hardly audible, and coming from a little disk of iron fastened to the centre of a membrane, whispered into the ear of one of the judges at the exhibition, and one of the greatest of living scientists, the tidings that a new revelation had descended upon mankind, and that the winged and fiery messenger of heaven's clouds had been harnessed to that delicate, tremorous, and yet so potent form of energy, called the Human Voice.

The speaking telephone had been born.

The stimulus which this event gave to science can best be measured by the enormous advance made since, especially in that now most prominent branch, electricity, and I will show further on how, immediately following it, our sister republic across the ocean answered the magic touch by the conception of another invention, the scope of which cannot to-day be measured yet, and which only just now is starting on its career of usefulness among the practical arts.

In order to show the influence which these two inventions had upon each other, and how their respective development came about in parallel steps, permit me, before entering upon the new methods which I am to bring before you to-night, to pass in rapid review on the principal events in the history of the

transmission of speech electrically, and of recording and reproducing the same mechanically.

In 1854, Charles Bourseuil, with more than usual boldness, advanced the idea that two diaphragms, one operating an electric contact, and the other under the influence of an electro-magnet, might be employed for transmitting speech over telegraphic distances. "Speak against one diaphragm," he said, "and let each vibration break or make the electric contact, and the electric pulsations thereby produced will set the other diaphragm vibrating, and the latter ought then to reproduce the transmitted sound." Outside of the fallacy which his theory contained in the assumption of breaking the contact, instead of merely modifying the same, Bourseuil's paper, in speaking of the diaphragm, laid stress upon stating that "if one could be invented so movable and flexible as to answer to all the undulations of sound." He evidently desired extreme flexibility, and diaphragms constructed on that principle proved fatal to the efforts of many subsequent experimenters; even at first to Mr. Bell, who, like Bourseuil, borrowed the idea from the flexible *tympanum membrani* of the human ear, and who overlooked the important modifications which the vibrations undergo, before reaching the auditory nerve, by the series of muscular hinges in which the various bony accessories of the ear are mounted, and which act as elastic dampers against the *tympanum membrani*.

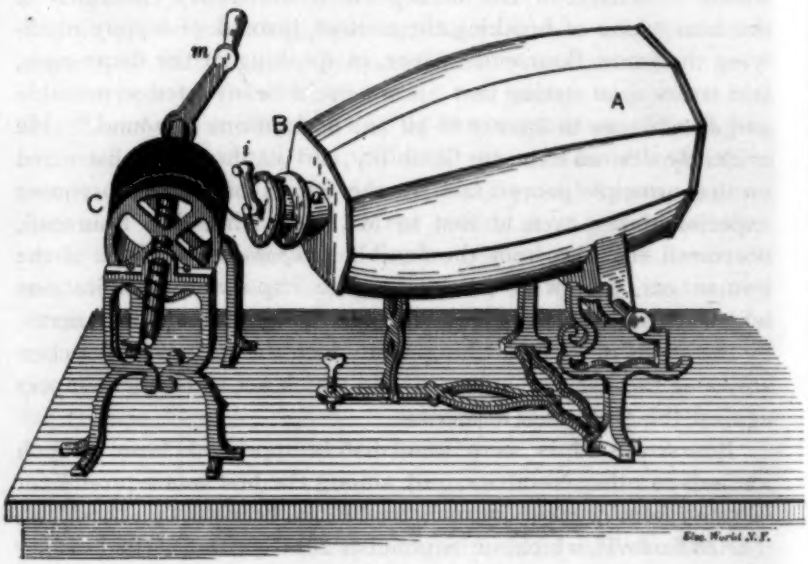
Bourseuil's ideas were immediately reprinted from French journals in other countries, and among the first was a prominent German semi-weekly journal, printed in Frankfurt-on-the-Main, *The Didaskalia*, which, on September 28, 1854, under the heading "Electrical Telephony," published a leading article, giving a full account of Bourseuil's ingenious and wonderful conception.

Frankfurt was then a city of about 60,000 inhabitants, and among other institutes of learning, it supported a Physical Society, which counted, at the time of this publication, among its active and most zealous members, an enthusiastic young teacher named Philip Reis, who, five years afterward, actually made an apparatus such as indicated by Bourseuil (who had since died without executing his idea), and which apparatus has since become known as the Reis telephone.

I will not now enter upon any controversy as to the scope of

this invention, regarding the possibility at the present day to transmit speech with the same. It may suffice to state that, when the news of the Bell telephone reached the learned men of Germany, some of the very first scientists in Berlin who knew all about the Reis apparatus, doubted the possibility of the performance as represented by the American press. It is also now a matter of history, that in the late decision in favor of Mr. Bell, the United States Supreme Court was unanimous so far as the Bourseuil-Reis apparatus was concerned.

FIG. 1.



Scott's Phonautograph.

While Bourseuil's conception was being digested by Reis, another invention, having also a membrane diaphragm as its motive principle, was patented in France in 1857. This was the phonautograph, by Léon Scott, which had for its purpose the recording of sound vibrations upon a cylinder rotated by hand and moved forward by a screw (Fig. 1). The cylinder was covered with paper, this was smoked over a flame, and a stylus attached to the centre of a diaphragm under the influence of words spoken into a large barrel-like mouthpiece, would trace sound vibrations

upon the smoky surface. Scott also employed an animal membrane for his diaphragm, and took pains, by means of an attachment called a sub-divider, to make the vibrations appear as large as possible. This sub-divider, however, became the prototype of the dampers in subsequent apparatus, like the Blake transmitter and the Edison phonograph.

The next important event in electro-phonic and acoustic science was the publication by Helmholtz of his investigations in sound, and of König in the same line of research, but classical as these publications will forever remain, they for a time retarded the progress of apparatus for practical use, for the reason that they discouraged inventors by the mechanical complications which they apparently ascribed as indispensable to articulate speech. In fact, the perusal of their work left a serious doubt in the mind of many a student, whether there was not something in articulate speech and its audibility by the human ear, beyond the grasp of the mechanical mind of man.

These doubts were still increased by the attempts of Faber to construct a talking machine, after the system of the human organs of speech, a mass of intricate mechanism, levers, bellows, and pulleys, which gave an unearthly rendition of many words and sentences.

But the Bell telephone came, and its greatness consisted not so much in the fact that it carried speech over hundreds of miles, but that it taught how simple a piece of apparatus could produce such perfect results, and that any diaphragm however thick, could be made to set up audible articulate vibrations.

The effect of this lesson was immediate, for hardly had the new wonder become known when an astonishing chain of logic formed in the brain of a distant devotee to science.

On the 30th day of April, 1877, Mr. Charles Cros deposited with the Secretary of the Academy of Sciences in Paris a sealed envelope, containing what in translation reads as follows:

"Process of Recording and of Reproducing Audible Phenomena."

"In general, my process consists in obtaining the tracing of the to-and-fro movements of a vibrating membrane, and the utili-

zation of this tracing for reproducing the same to-and-fro movements, with their relative inherent durations and intensities in the same membrane, or in another adapted for furnishing the sounds and noises which result from this series of movements.

"We are, therefore, concerned with the transformation of an extremely delicate tracing, such as that obtained with a delicate stylus rubbing upon a surface blackened by a flame, to transform, I say, these tracings in relief or intaglio, in resisting material capable of guiding a moving body, which transmits these movements to the sonorous membrane.

"A light stylus is connected with the centre of a vibrating membrane; it terminates in a point (metallic wire, the barb of a feather, etc.), which bears upon a surface blackened by a flame. This surface is a part of a disk to which is given a double movement of rotation and rectilinear progression.

"If the membrane is at rest, the point will trace a simple spiral; if the membrane vibrates, the traced spiral will be undulating, and these undulations represent exactly all the to-and-fro movements of the membrane, with their times and intensities."

Up to this point the apparatus as described would represent a modified Scott phonautograph, in which the cylinder is substituted by a flat disk. Mr. Cros then continues:

"By means of the photographic process which, in fact, is well known, this traced, transparent, undulatory spiral is converted into a line of similar dimensions, in intaglio or in relief, in resisting material like tempered steel, for instance.

"This done, this resisting surface is, by means of a motor apparatus, made to turn and to progress rectilinearly with a velocity like that which was used in the registration.

"If the reproduced tracing is in intaglio, a metallic point (and if it is in relief, a notched finger), held by a spring, bears upon the tracing at one end and is connected at the other end with the centre of the membrane adapted for sound reproduction. Under these conditions, this membrane is not any more acted upon by the vibrating air, but by the tracing controlling the pointed stylus by pulsations exactly like those to which the membrane was subjected in recording, both as to duration and intensity.

"The spiral trace represents the successive equal periods by its increasing and decreasing length. There is nothing inconve-

nient in this if only the outer portion of the rotating circle is used, and if the spirals are close together, except that the central part of the disk is lost.

"In all cases, however, a helical tracing upon a cylinder is much to be preferred, and I am actually engaged in finding a practical embodiment of this."

This paper was only read in open session at the Academy on December 3, 1877, and in the meantime Mr. T. A. Edison appeared with the phonograph.

From what we can learn by published reports, Mr. Edison, some time in the latter part of September in the same year, was at work on an automatic telephone, by which he intended to impress a telephone message upon a strip of tin-foil, and let the indentations thereby produced act upon a variable resistance, such as a lampblack button, and thereby transmit the message over the wire. While one day at work on this, so the report runs, he, perchance, slipped the previously indented slip under the recording stylus which, as in the Scott phonautograph, was connected to the centre of a diaphragm, and then and there occurred the first actual reproduction by mechanical means of words registered before.

The phonograph became then, at once, an accomplished fact, for to such an experienced inventor it must have taken but a moment to mentally cover the cylinder of a Scott phonautograph with tin-foil and to indent the same at right angles to the surface of the cylinder.

Everybody remembers the sensation which the invention produced, and the prognostications which were advanced for it by the scientific press showed that the principle of the apparatus was considered to contain the germ of an ultimate achievement of the most accurate results.

In this respect, as well as in others, there are striking resemblances in the history of the two inventions with which I am dealing.

In both, the original idea emanated from Frenchmen, and both described one process of transmitting, and a different process of reproducing speech. In the Bourseuil telephone there was a contact transmitter and an eloctro-magnet receiver; in the Cros

phonograph, a written record and an engraved reproducing groove.

In both inventions the first realization occurred in the United States, and was effected with apparatus representing only the reproducer of the original conception. In the speaking telephone, the reproducing electro-magnet of Bourseuil became also the transmitter of Bell, and in the phonograph, the reproducing groove and stylus of Cros became also the record of Edison. Both the Bell and Edison apparatus were accepted for a time as containing the best mechanical and philosophical principle for the highest attainable results. In both, the aim at the beginning was to produce loud sounds, and both eventually contented themselves with a much fainter voice, which then became more distinct in articulation. Finally, in both inventions, the original transmitter was subsequently resurrected, and found to contain a pointer toward a superior principle as a transmitter and recorder, and it only remains now to use a Scott phonautographic record direct for reproduction in order to complete a parallel with the fact that a contact transmitter can also be used as a telephonic reproducer.

In making these parallels, however, I am aware of the fact that Cros had a better idea of a talking machine than Bourseuil had of a speaking telephone.

The paper of Mr. Cros, which can be found on page 1082, vol. 85, of the *Comptes Rendus* of 1877, appears to have been consigned immediately to obscurity. When ten years later, I filed my patent application for the gramophone, not even the Examiners at the Patent Office knew anything of Mr. Cros, and when I mentioned his name in the first publication of the "gramophone," even those best informed on the subject were surprised. Nevertheless, I considered it a duty to my friends to make the following statement to the Editors of *The Electrical World*, which they published simultaneously with the "gramophone," on November 12, 1887. I said:

"On August 30, of this year, which was three months after the filing of my application for a patent, while in the office of my counsel, Mr. Joseph Lyons, I happened to look through a German scientific book in his possession, and reading up about the phonograph, I came across a remark stating that on April 30,

1877, one, Chas. Cros, deposited at the French Academy of Science a sealed paper which, when opened and read at a subsequent session during that year, was found to contain a description of the author's idea that a photo-engraved phonautographic record, either in relief or intaglio, might be utilized 'for reacting through a stylus on a diaphragm, and by this reaction ought to reproduce the original sound.'

"Surprised as I was at this discovery, I requested Mr. Lyons to find out through his friends in Paris whether and to what extent Mr. Cros had ever carried his idea into practice, and an answer has since come to the effect that Mr. Cros never put his idea into practical operation.

"Whether he was taken aback by the *éclat* which the phonograph produced soon afterward; whether he became discouraged at the practical difficulties, of which I have found many at the outset of all my experiments; or whether he did not appreciate the peculiar advantage of the phonautogramic method—all this does not appear from the meagre accounts so far to hand.

"But although, viewed in the light of equity, he had virtually abandoned his invention at the time when I independently and without knowledge of his prior idea took up the same subject, the fact remains that to *Mr. Charles Cros belongs the honor of having first suggested the idea of, and feasible plan for, mechanically reproducing speech once uttered.*"

As this statement has never been challenged since it was first made, I presume that it is substantially correct.

If we should attempt to carry out strictly the ideas of Mr. Cros, we would find many obstacles to obtaining practical results, and while undoubtedly the correctness of the general principle could be proved, the effects would not be as good even as those obtained by the original phonograph. Even with the application of the various improvements which I originally introduced, the process requires great care, and while this would not have been an obstacle on account of the great advances made in photo-engraving, I have now abandoned the original process altogether, and have substituted one of great rapidity and simplicity.

But to return to the phonograph, we find this apparatus remained in an unsatisfactory and unfinished condition for nearly nine years.

Among those who believed that ultimately the phonograph could be turned to practical account, was the well-known original patron of the speaking telephone, Mr. Gardiner G. Hubbard, and being also financially interested in it, he, in 1883 or thereabouts, caused the Volta Laboratory Co., an association originally founded by Prof. Bell as a laboratory, from the funds of the Volta Prize awarded to him by the French government, to provide ample funds for the purpose of making an extensive series of experiments with the phonograph.

Prominent among the scientists connected with the enterprise were Prof. Bell, Dr. Chichester A. Bell, and Mr. C. S. Tainter. After two years of ardent labors these gentlemen came to the conclusions:

First. That the indenting process had to be abandoned and an engraving process be substituted—*i. e.*, instead of pushing the record surface down with the stylus, as in the original phonograph, it should rather be dug out or graven into.

Second. That the best substance, answering also the various other requirements, was beeswax hardened by an admixture of paraffine, or other similar waxy substances.

Third. That loud speaking was impracticable, and that the ordinary conversational tone gave better results, although reducing the reproduction to the loudness merely of a good telephone message.

In Patent No. 341,214, of May 4, 1886, issued to Dr. Chichester A. Bell and Mr. C. S. Tainter, the following claims, among others, were granted:

"The method of forming a record of sounds by impressing sonorous vibrations upon a style, and thereby *cutting* in a solid body the record corresponding in form to the sound waves, in contradistinction to the formation of sound records by indenting a foil with a vibratory style, etc.

"3. The vibratory *cutting* style of a sound recorder; substantially as described.

"7. A sound record consisting of a tablet, or other solid body, having its surface *cut or engraved* with narrow lines of irregular and varied form, corresponding to sound waves substantially as described.

"9. The method of forming a sound or speech record, which

consists in engraving or cutting the same in wax, or a wax-like composition; substantially as described."

As a final result of all their labors, there issued in the spring of 1887, the graphophone, the first really practical apparatus of the phonograph type, and which was exhibited to admiring crowds in Washington and elsewhere.

To those who have never heard this instrument, I will repeat what I wrote about its performance in November, 1887, namely, that it appears to be the best instrument to take down business letters or dictations of any kind, in which the recognition matters little, so long as the words can be made out; also, that the reproduced sound is as loud as that of a good telephone message, but that the distortion produced by the engraving is sufficient to make the voice unrecognizable save to a strained imagination added to a previous knowledge of the author of the voice. The record ground of this machine is a thin pasteboard cylinder covered with wax.

Soon after the graphophone became generally known, Mr. Edison, evidently encouraged by the results obtained in this instrument, took again to experimenting with the phonograph, and, after trying wax covered with tin-foil for indentation, he abandoned that mode of recording, and also settled upon a cylinder of wax and the graving-out process, thus confirming the correctness of Bell and Tainter's conclusions, and the new Edison phonograph and the graphophone appear to be practically the same apparatus, differing only in form and motive power.

I now come to the subject of the evening, the Gramophone.

In my telephonic studies, I had become familiar with all the causes influencing the transmission and reproduction of the voice, and what had at all times struck me as forcibly as anything in telephonic phenomena, was the fact that the self-induction of long iron wires or of polarized electro-magnets acted so detrimentally upon the articulation. Electrical resistance alone would simply have weakened the sound, but self-induction meant retardation, and this distortion of the transmitted waves which varied in length and amplitude. To appreciate fully what an extremely small amount of energy ordinary speech possesses mechanically, let us consider a few well-known facts:

A puff of air, not strong enough to extinguish a candle-flame,

when blown across an empty bottle or into a whistle will produce a sound which may be heard over a hundred feet away. The amount of electricity needed to operate audibly a magneto-telephone, is said to be less than one-millionth part of the electricity of a standard Daniel cell.

In considering such and other facts it became evident to me that if such delicate energy, subdivided into maybe several hundred waves, should indent or engrave itself into a solid body, it needed but very slight mechanical resistance to modify considerably the character of the sound vibrations. For what self-induction is to the telephone circuit, the variable resistance which impressible material offers to indentation or engraving at various depths is to the phonograph record sheet. Neither is proportional in direct ratio to the expended energy and must give cause, aside from a reduction in size of the sound characters, also to a distortion of the same.

Your own Prof. Houston, in his learned remarks in the JOURNAL OF THE FRANKLIN INSTITUTE of January, 1888, says:

"The difficulties just pointed out, it would seem, must exist in any instrument, however improved in its mechanical structure, if it make the record on the Phonogram at right angles to the surface thereof. Of course, if a substance was discovered for such a surface, that offered a resistance to indentation exactly proportional to the depth of such indentation, the difficulty would, to a great extent, be removed."

All the experiments which were made with the phonograph and the graphophone, confirmed the correctness of all these assertions, for the louder it was necessary to speak when recording, the less distinct became the articulation of the reproduced sound.

A change for the better was, therefore, to be obtained:

First. By tracing the vibrations, as in the old phonautograph, parallel to the record sheet.

Second. By reducing the resistance offered by the record medium to as near to nothing as possible.

Both principles, although not emphasized, are contained in the Cros document; but for my part, I found that merely smoked surfaces were utterly impracticable, because, if sufficiently black for a photo-engraving, and with the extremely small sizes of

waves obtained with records that are adaptable for the reproduction of good articulate speech, the record lines were ragged, and, under a magnifying glass, looked like a set of parallel saws whose teeth would form a grating sound, which nearly drowned the articulation.

I observed, however, in my experiments, that the grayish deposit of lamp-black which is obtained from the centre of a kerosene flame was more oily and gave a somewhat sharper line than the deep black deposit caused by smoking with the top of the flame, and this led me to the highly beneficial process of oiling the plate prior to smoking the same, either by applying printers' ink or artists' paint by means of a printers' roller or by brushing oil over it. The smoke would then amalgamate with the oil and forms a *fatty ink* of a rather dry consistency, which, when crossed by a stylus, shows, even under a microscope, a sharply cut transparent line.

I still employ this process for small test plates and prepare them as follows: One part of paraffine oil is mixed with twenty parts of benzine or gasoline. This mixture is poured on and off a glass disk, when the benzine evaporates leaving an extremely thin layer of oil. This is held over a smoky flame and moved to and fro until the surface looks *just* dry. The application of artists' paint with a roller prior to smoking is still better.

I also adopted for the gramophone a disk of glass as a support for the smoke deposit, traced the sound record from below so that the displaced lamp-black should fall down, varnished it after the tracing was done and used this disk as a negative without, therefore, needing a camera or photographic chemicals outside of the chrome-gelatine or chrome-albumen used in developing a raised picture. I would refer, for a detailed account, to the already mentioned issues of *The Electrical World* and the JOURNAL OF THE FRANKLIN INSTITUTE.

The lesson of simplicity which the telephone was continuously preaching caused me at an early day to look for a simpler plan to attain my purpose, and in the specification originally filed by me I said:

"This record (meaning the phonautogram) may then be engraved either mechanically, *chemically*, or photo-chemically." And although for a long time without much hope for success, the

purely chemical process of direct etching haunted me continuously, and was repeatedly suggested by others.

But it was easier suggested than carried out, because under the principles of the gramophone the etching ground was to offer practically no resistance to the stylus, and to make one which had no resistance mechanically, but did resist the etching fluid after the tracing was done, was the problem to be solved.

You will readily see, that if we can cover, for instance, a polished metal plate with a delicate etching ground, trace in this a phonautogram and then immerse the plate in an etching fluid, the lines will be eaten in and the result will be a groove of even depth such as is required for reproduction; such a process, of course, would be much more direct and quicker than the photo-engraving method.

In nature provision seems to be made for all the wants of mankind, and confident in this belief, I kept on trying to find a trail which led to promising results, and I have the honor to-night, for the first time, to bring before you this latest achievement in the art of producing permanent sound records from which a reproduction can be obtained, if necessary, within fifteen or twenty minutes, and which can be accurately multiplied in any number, by the electrotype process. It may be termed, in short, *the art of etching the human voice.*

The etching ground which I use is also a fatty ink, and one of the best I have found thus far is made by digesting pure yellow beeswax in cold gasoline or benzine.

Benzine, in a cold state, will not dissolve all the elements of the wax, *but only a small part*, namely, that which combines with the yellow coloring principle, and the resultant and decanted extract is a clear solution of a golden hue, which gradually becomes bleached by exposure to light. The proportions which I use are one ounce of finely scraped wax to one pint of gasoline. The bottle containing the mixture must be repeatedly shaken, and, after the white residue has settled, the clear fluid is decanted or drawn off by a siphon.

I then take a polished metal plate, generally zinc, and flow the fluid on and off, as if I would coat with collodion. The benzine will quickly evaporate, and there remains a very thin layer of wax, iridescent under reflected light, not solid as a coating pro-

duced by immersion in a melted mass, but spongy or porous, and extremely sensitive to the lightest touch.

Partly on account of the too great sensitiveness of a single film, and also as an additional protection against the action of the acids employed in the subsequent etching, I may apply a second coating of the solution, and this double coat I find to answer all requirements.

The protection which this porous or spongy wax affords from the acid, is mostly due to the fact that watery solutions assume the spherical state on the film, while at the lines where the wax is disturbed the acid enters freely, and attacks the metal below.

A difficulty, which only a short time ago appeared insurmountable, was the accumulation at the point of the stylus, while tracing the sound record, of filamentary particles of dust which exist in the wax solution, and which being ever present in ordinary rooms, settle down and adhere to the film. These dust particles are so fine that they cannot, as a rule, be detected by the most searching inspection of the prepared plate; but they become very conspicuous, and a very serious source of annoyance when a long record is being made.

It must be borne in mind that the contact which the tracing stylus makes with the record surface, is obtained by the elastic pressure from a piece of hair-spring backed by a narrow blade of writing paper, and which pressure amounts to about five grains. Therefore, as this stylus passes through the fatty ink or other ground, and traces the fine undulatory line, the dust particles, as well as small portions of the displaced ink or wax adhere to and accumulate at the point of the stylus and are dragged along, and the record thereby becomes blurred and indistinct.

I have discovered an effective means for overcoming this difficulty, and it consists in applying to the record surface a fluid that slightly adheres to the etching ground, and keeps it wet while the record is being made. I have found commercial alcohol to be very effective for this purpose, and it is used by pouring it over the plate just before the sound record is made. The alcohol, of course, immediately commences to evaporate, but not rapidly enough to disappear entirely before the record is finished, and there is no difficulty in adding more alcohol while the plate revolves. Under this condition, the point of the stylus remains

perfectly clean, and it seems as if the dust particles had not been present at all.

The theory by which I explain this result is, that the alcohol, so to speak, lubricates both the surface and the stylus, and prevents the adhesion of the filaments to the latter. At any rate, the application is highly beneficial, and the resulting line is so sharp and fine that it has to be widened in the subsequent etching process, in order to permit the acid to bite at sufficient depth. It can also be proved that the resistance of the wax film is decreased by the presence of the alcohol, but when this has evaporated the wax film appears to be in precisely the same condition as before, even showing again the iridescent colors which disappeared on the application of the alcohol.

The film of wax being so thin, it is almost transparent, and if th erecord was made on this it could barely be detected. As, however, it is sometimes desirable to examine the record prior to etching the same, I can smoke the etching ground slightly by holding it high above burning camphor, so as to prevent a heating and melting of the spongy wax, and the alcohol poured afterwards over this smoked surface does not seem to wash off any of the soot particles.

We now come to the important process of etching the record. Etching is done on steel, copper, or brass with nitric acid, perchloride of iron, or with a mixture of muriatic acid and chlorate of potash known as Dutch mordant. In modern photo-engraving nearly all the etching is done on zinc by means of diluted nitric acid, and these materials are preferred on account of their being cheaper than any other, and zinc is a metal easily obtained with smooth and even facings. In etching, however, on zinc, it is necessary continually to brush away the hydrogen bubbles which form and adhere to the lines, and as the etching ground is usually of firm and solid material (like asphaltum, hard wax, pitch, or rosin mixtures) no harm results from the brushing necessary in order to obtain sharp edges along the lines.

Desiring to avail myself of the advantages offered in zinc plates, I soon found that no etching fluid was known that would be to zinc what perchloride of iron was to copper—namely, etch cleanly and without the appearance of hydrogen bubbles. To apply the brushing to the delicate spongy wax film

I employed was out of the question, as the first touch would wipe away the whole ground, and to permit the formation of hydrogen bubbles without brushing them away meant uneven and ragged lines and a distorted record.

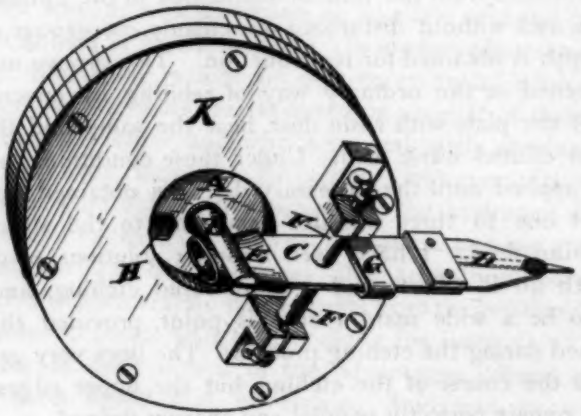
While studying this matter over it occurred to me to, so to speak, depolarize the zinc plate by adding to the acid, bichromate of soda which I thought might prove efficient, as it does in the galvanic battery, to prevent the appearance of the bubbles while etching the zinc. It took, however, a comparatively large quantity of the bichromate to answer my purpose, so much that I concluded that the mixture had all the conditions of a chromic acid, or at least of a mixture of chromic acid and nitrate of soda. When I thereupon substituted a solution of chromic acid pure and simple, I found this to be a most excellent etching fluid, and that is what I am now using—namely, a solution of one part by weight of dry chromic acid dissolved in three parts by weight of water. I use the commercial acid, such as can be obtained from Churchman & Co., of this city, at twenty-five cents a pound. Such a solution etches on zinc a sharp and clearly cut line, and no hydrogen appears during the etching.

The back of the zinc plate had previously been painted with protecting varnish or molten beeswax, and within from fifteen to twenty minutes from the time of immersion in the chromic acid solution, and without disturbing it a cleanly cut groove of sufficient depth is obtained for reproduction. This groove may then be deepened in the ordinary way of rebiting by covering the facing of the plate with rosin dust, heat the same, and then immerse in diluted nitric acid. Under these conditions the brush may be applied until the necessary depth is obtained, generally in about one to three minutes according to the strength of the etching fluid. I have used stronger solutions of chromic acid with no ill effects and a more rapid etching, and there seems to be a wide margin on this point, provided the plate is watched during the etching process. The lines very gradually widen in the course of the etching, but the upper edges of the grooves remain perfectly parallel and sharply defined.

Before proceeding with a practical demonstration of the whole process, I will now describe the most important apparatus of the gramophone, the recorder. The translation of the movements of

the diaphragm into the same movements at right angles, and with the extreme smallness of the motion and the liability of distorting them, adding to them, or detracting from their value in translating them, requires greater care to guard against error than an uninitiated observer would suppose, and when we examine the complex and extremely delicate mechanism which nature has provided in the human ear for giving a correct translation of air vibrations into nervous vibrations, it behooves us to be careful in the application of every day mechanics. Free as the telephone is, comparatively, from mechanical incumbrances, it is deficient in articulation of the consonants, and with the simplicity of mounting as required in the phonograph and graphophone, these difficulties of recording proper do not exist, and are shifted to the other portions of their construction and manipulation. In having attempted, therefore, to do justice to all sources of error I am not yet prepared to say that my present recording apparatus is constructed and adjusted to the greatest attainable correctness. Those who are familiar with the tediousness of original research will admit that a new subject of this kind cannot be solved in its entirety within the space of a few months, and what I bring before you to-night being the hasty results of a new machine finished but ten days

FIG. 2.



ago, should be measured rather by the possibilities it opens, than by the results so far attained, whatever merit you may accord to them.

My impression, however, is that there is very little of lost or added motion in my present apparatus, and whatever imperfections may exist must be looked for in the mode of reproducing the sound, rather than in the recorder (Fig. 2).

K is the diaphragm box; *A* is the centre portion of the diaphragm; *B* is a brass post screwed to the diaphragm and slotted above; *E* is a piece of rubber tubing held in the slot and holding one end of the stylus *C*. This stylus is made of stiff metal and is pivotted by the steel pivots *F F*. *D* is a blade of writing paper reinforced by a piece of hairspring which extends, and forms the tracing point. *G* is a piece of rubber tubing around the stylus which dampens its musical vibrations; *H* is a piece of felt damper between the diaphragm and the diaphragm box, which acts as a general damping device.

The whole is mounted on a sliding carriage, which is drawn by clock-work across the disk, while the latter revolves at the rate of about thirty revolutions per minute.

DEMONSTRATION.

While the plate is being etched I will now let you listen to some phonautograms which I prepared in Washington within the last two weeks. The reproducing apparatus, or sounder, is constructed on precisely the same principles as the recorder, but of smaller dimensions and with more rigid mountings, so rigid, in fact, that if it was used as a recorder it would barely show undulations on a smoked surface when shouting into it.

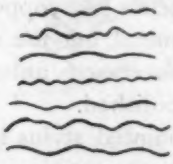
The stylus is tipped with iridium like the points of a gold pen, the object of this being to prevent abrasion by the continuous friction with the hard record.

In reproducing the sound, I find that it is louder with hard contact substances, like metal, than with soft ones like rubber or plaster-of-Paris. Hard metals like copper, nickel, or brass, sound louder than zinc or type-metal, but the scraping sound, which is due to friction, is also increased unless the record surface is smooth and very highly polished.

But when an iridium-pointed stylus is rubbed over clean glass a scraping sound is barely perceptible. I am now in communication with a firm that is making ornamental glass tiles by im-

Recording Diaphragm and Stylus.

Reproducing Apparatus.



Record lines (magnified 6 diameters).

pressing upon red-hot glass plates fancy designs in relief or intaglio by strong pressure. You will readily see that if on the same plan we can impress a matrix showing the sound record in raised lines upon a glass plate, we would get a groove, in glass giving a loud reproduction with a minimum of disturbing sound due to friction.

In the description of November 12, 1887, I advanced the idea of mounting the sounder on a carriage and rails, and have the record groove itself be the screw which was to guide the point of the stylus across the disk from periphery to centre. This has been improved upon by Mr. Werner Suess, the gentleman with me here to-night, and who is the mechanician of our little shop in Washington. He suggested to mount the sounder on a pivot at some distance from the disk and then let the reproducing groove guide the sounder across the disk over an arc of flat amplitude. This happy idea is embodied in the present apparatus, and is a very ingenious adaptation indeed.

REPRODUCTION.

It is, I trust, pardonable if I close by foreshadowing to a certain extent the practical applications of the gramophone.

A standard reproducing apparatus, simple in construction, and easily manipulated, will, at a moderate selling price, be placed on the market.

Those having one, may then buy an assortment of phonautograms, to be increased occasionally, comprising recitations, songs, and instrumental solos or orchestral pieces of every variety.

In each city there will be at least one office having a gramophone recorder with all the necessary outfits. There will be an acoustic cabinet, or acousticon, containing a very large funnel, or other sound concentrator, the narrow end of which ends in a tube leading to the recording diaphragm. At the wide opening of the funnel will be placed a piano, and back of it a semicircular wall for reflecting the sound into the funnel. Persons desirous of having their voice "taken" will step before the funnel, and, upon a given signal, sing or speak, or they may perform upon an instrument. While they are waiting the plate will be developed, and, when it is satisfactory, it is turned over to the electro-

typer, or to the glass moulder in charge, who will make as many copies as desired.

The electrotype shells are mounted on thick pasteboard, and this is backed by a stiff piece of sheet metal. There is another process which may be employed. Supposing that his Holiness, the Pope, should desire to send broadcast a pontifical blessing to his millions of believers, he may speak into the recorder, and the plate then, after the words are etched, is turned over to a plate-printer, who may, within a few hours, print thousands of phonautograms on translucent tracing paper. These printed phonautograms are then sent to the principal cities in the world, and upon arrival they are photo-engraved by simply using them as photograph positives. The resultant engraved plate is then copied, *ad infinitum*, by electrotyping, or glass moulding, and sold to those having standard reproducers.

Prominent singers, speakers, or performers, may derive an income from royalties on the sale of their phonautograms, and valuable plates may be printed and registered to protect against unauthorized publication.

Collections of phonautograms may become very valuable, and whole evenings will be spent at home going through a long list of interesting performances. Who will deny the beneficial influence which civilization will experience when the voices of dear relatives and friends long ago departed, the utterances of the great men and women who lived centuries before, the radiant songs of Patti, Campanini, Nieman, and others, the dramatic voices of Booth, Irving, and Bernhardt, and the humor of Whitcomb Riley can be heard and re-heard in every well-furnished parlor?

Future generations will be able to condense within the space of twenty minutes a tone picture of a single lifetime. Five minutes of the child's prattle, five of the boy's exultations, five of the man's reflections, and five of the feeble utterances from the death-bed. Will it not be like holding communion even with immortality?

POSTSCRIPT: One of the peculiarities inherent with the gramophone is the possibility to enlarge the original sound by enlarging the printed vibratory characters of speech and then photo-engrave

the same. In this manner it should be possible to get the reproduction at a much greater volume than the original sound. It would be interesting if some day speakers in a large hall would prefer to do their talking by machine, or to send speeches to a convention which they were unable to attend in person.

E. B.

[At the close of the paper and after the exhibition of the apparatus, Prof. E. J. HOUSTON moved a vote of thanks to MR. BERLINER for his interesting and valuable communication. The motion was carried unanimously, and the meeting was adjourned.]

THE PILOT CHART OF THE NORTH ATLANTIC OCEAN,

ISSUED MONTHLY BY THE UNITED STATES HYDROGRAPHIC OFFICE.

BY EVERETT HAYDEN, in charge of the Division of Marine Meteorology, United States Hydrographic Office.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *January 27, 1888.*]

Concluded from Vol. CXXV., page 278.

Perhaps the most characteristic as well as the most important data published on the chart are the "red data," comprising as they do all matters of special immediate importance and interest. The final proof of this impression is corrected and revised at the last moment before going to press, for this portion of the chart aims to give the latest and most trustworthy *news* regarding various subjects of great importance to navigators. The long list of Notices to Mariners gives, in brief, the title of each notice published during the month just passed, indexed in such a way that each one can be readily referred to and called for by number. These notices can be obtained, free of charge, at any branch hydrographic office, and the master of a vessel about to sail for a distant port can consult this list and obtain the latest information regarding the navigation of the waters which he has to traverse.

The preparation of these notices, of which only the titles are given in this list, is carried on by the Division of Sailing Directions, and is a work of great magnitude, involving the most painstaking care, accuracy and thoroughness. Hydrographic information received from various foreign offices, correspondents and publications, must be quickly and carefully collated, verified and prepared for publication according to the prescribed form and the proof very carefully corrected, for this is a case where a slight error in a single figure may make an item worse than useless. The same may be said regarding the next column, a list of dangerous obstructions to navigation along the coast. The stranded wrecks, whose positions and descriptions are stated as accurately and yet as concisely as possible in this list, constitute each one a dangerous obstruction, all the more dangerous because not shown on any chart, nor, in most cases, marked by any buoy to warn the navigator. Except among those whose profession compels them to recognize the fact, it is not generally known that a sunken and dismasted wreck near the coast may be a source of danger for months, and even years, to other vessels. For this reason, every effort is made to keep this list corrected up to date by means of all available information, and whenever a suitable opportunity occurs, a naval vessel is detailed for the purpose of blowing up or otherwise removing one or more of these obstructions, guided by information furnished by the Hydrographic Office. Then follows a list of charts published during the preceding month, and a list of those that have been cancelled for one reason or another, and are no longer issued. Here again we are given an insight into the workings of another and perhaps the most important of all the Divisions of the Hydrographic Office, the Division of Chart Construction. Had I an entire evening to devote to this one subject, I could hardly begin to give even an outline of all the scientific principles, and the exact and refined mechanical processes, involved in the preparation of one of the large copper plates from which these hydrographic charts are printed. Although the mere estimated cost in dollars and cents of the material, drafting and engraving is but a poor index to the amount of skill, labor and expense which each of these copper plates represents, it must suffice to say here that the estimated cost of a single plate (H. O. Chart No. 981, S. E. coast of Nova Scotia, etc.), including cost of changes and

corrections charged up against it, is $1,672.10, and that there are now on hand, carefully stored away in readiness for use as occasion demands, 429 plates, each of which must be carefully corrected up to date by constant reference to all the latest information received, in order that the office may always be in readiness to print new editions of any chart that may be called for. Thus the Pilot Chart, although published under the supervision of the Division of Marine Meteorology, records and publishes an abstract of the work which is being carried on in each division of the Office, in order that the results may be known and thus made available for immediate practical use.

The remaining space on the chart, available for printed matter, is devoted to such matters of special interest as come up from time to time, and to the publication of anything which it is desired to force upon the notice of navigators in such a way that it cannot be overlooked or forgotten. Perhaps the most notable success that has been achieved in this way has attended the publication of notices recommending the use of oil to prevent dangerous seas from breaking on board vessels—a source of very great danger during heavy weather. Without any exaggeration, it may be safely said that the revival of the knowledge of this old but forgotten principle, brought about within the last few years by means of such notices published on the Pilot Chart, has been of incalculable benefit to the commerce of the world. Let me quote a few such reports which have been published on the Pilot Chart during the past year:

Captain Campbell, American steamship *Knickerbocker*, was caught in the hurricane of August 22d, latitude 33° 23′ N., longitude 75° 15′ W. At 9 P. M. of the 23d, shipped heavy sea on port side, smashing in bulwarks; later, shipped sea on starboard side, washing away port life boat, gangways, fire buckets and racks, after compass, two ventilators, and stove out bulwarks. At 1.30 A. M., August 24th, frightful cyclone from W.NW., velocity approximately 100 miles, immense cross sea, ship laboring heavily. At 5 P. M. steering gear carried away. Used whale oil in sacks over weather (starboard) quarter to lessen the effects of heavy seas, with complete success, vessel riding easier while repairing. Captain Campbell speaks with enthusiasm as to the efficacy of oil.

Captain Brown, American barkentine *Josephine*, reports: August 27, 1887, passage from Turk's Island to Philadelphia, in a frightful sea, when it was almost impossible to get forward or aft, and utterly impossible for the cook to keep fire in the galley, as the vessel was putting her bows right under and

throwing heavy bodies of water aft, flooding the forward house and cabin and carrying away the port fore rigging and backstays, put raw linseed oil into bags in the usual way (one on the cathead and another in the main rigging), and after this the decks were comparatively dry.

Captain Morgan, British steamship *Blackwater*, encountered a terrible gale November 1st, near Liverpool, during which his vessel shipped a great deal of water. The seas were frightful. At one time it is estimated that the steamer had 100 tons of water on deck. Deciding to return to Cardiff for shelter, he stationed a hand at each bow to pour oil upon the water, when the seas, which had been most turbulent, ceased to break over the vessel. On more than one occasion it seemed as if nothing could prevent her from foundering, but Captain Morgan attributes her safety chiefly, if not solely, to the judicious use of oil.

With such items before him day after day as the navigator plots the track of his vessel on the chart, it is not surprising that thousands of mariners have been induced to try the experiment for themselves, and, whatever theorists may say to the contrary, it needs but a single trial to convert the most skeptical. As a result, the importance of this simple and inexpensive precaution is now recognized by every commercial nation, and no master of a vessel can afford to neglect it when heavy broken seas threaten to come on board. It is interesting in this connection to read what eminent foreign authorities say on the subject. Vice-Admiral Cloué, of the French Navy, in a recently published pamphlet, uses these words: "Between 1830 and 1840, several Dutch savants studied the subject carefully, and, having become convinced of the efficacy of the use of oil, induced certain sea captains to try this method of quieting the sea. But with the exception of a few cases where it was used successfully between 1845 and 1870, of which details are wanting, nothing was done. The question appears to have been forgotten until the Hydrographic Office at Washington took it up within the last few years, when it was pushed so vigorously and persistently that it is extremely unlikely ever again to fall into oblivion. By so doing, the Hydrographic Office at Washington has rendered an immense service to all seafaring men, and has placed them under great obligation." In a brief review of this pamphlet, Capt. W. J. L. Wharton, R. N. Hydrographer to the British Admiralty, writes as follows: "That the great effect produced by oil in smoothing troubled waters should have been so well known in times past as to have passed into a proverb, and yet that no general practical use of this effect should have been made until the last few years, is

a remarkable instance of the tardiness of mankind to apply the benefits that natural phenomena provide. To the Hydrographic Office of the United States is mainly due the credit of bringing into prominence, and forcing on the notice of seamen, in various publications, the great importance of this property of oil under circumstances when life and property are endangered by breaking seas, and the extreme facility and trifling expense of its employment. Thanks to the efforts of the Americans, the facts are now well known to all English-speaking mariners, and many are the instances of the successful use of oil; but, nevertheless, the prejudices of many are still against it."

The only remaining printed matter accompanying the red data is the brief weather review of the preceding month, published in the lower right-hand corner of the chart. This is prepared from all reports received up to the time of going to press, and gives, in connection with the storm tracks plotted on the chart, as complete a review as can be given from the data at hand.

In this description of the red data I have left to the last what may perhaps be regarded as the specially characteristic and interesting feature of the Pilot Chart. Derelict vessels, wrecks and drifting buoys constitute formidable obstructions to navigation at sea; indeed, it is not generally realized how long a derelict may keep afloat and pursue its aimless course at the mercy of the winds and currents of the ocean. To illustrate, let me quote three instances, the first two from the Pacific ocean, and the third from the North Atlantic:

Ship *Ada Iredale*, voyage from Androssan, Scotland, to San Francisco, was burned in the South Pacific through the spontaneous combustion of the coal with which she was laden. Abandoned October 15, 1876 (latitude 13° 30′ S., longitude 107° 45′ W.), about 1,900 miles east from the Marquesas Islands. The crew of twenty-three men reached the Marquesas group in twenty-five days, with the loss of one man and one of their three boats. The still burning wreck of the vessel drifted slowly to the westward, in the south equatorial current, to Tahiti, Society Islands, 2,423 miles distant, and was towed into port by the French cruiser *Seignelay*, June 9, 1877. She continued to burn till May, 1878, when she was repaired, and, as a handsome bark named *Annie Johnston*, has done good service in the trade with China. Drift, 2,423 miles; time, nearly eight months.

Ship *Oriflamme*, abandoned on fire in June, 1881 (latitude 18° 12′ S., longitude 92° 42′ W.). On October 24th, the steamship *Iron Gate*, voyage from Adelaide, Australia, to Portland, Oregon, passed, in latitude 13° 27′ S.,

longitude 125° 19′ W., an iron ship apparently burned, no masts standing; sent a life-boat alongside, but could see no signs of life. February 12, 1882, the hull of an iron ship, laden with coal and iron, drifted ashore on the Island of Raroia, one of the Paumotu or Low archipelago (latitude 15° 55′ S., longitude 142° 12′ W.). She was visited by some natives, who brought away a small bell upon which was engraved *Oriflamme, 1865*. She was completely burned out, and in a short time sunk in deep water. Drift, 2,840 miles; time, about eight months.

Abandoned schooner *Twenty-one Friends*. First reported March 24, 1885, about 160 miles off the capes of Chesapeake Bay (latitude 36° 45′ N., longitude 72° 40′ W.). The Gulf Stream carried her in a direction about E. NE. to latitude 51° 30′ N., longitude 27° 40′ W. (2,130 miles in four and one-half months). Thence she drifted in an easterly and southeasterly direction towards the northern coast of Spain, and was last reported December 4th, of the same year, in latitude 45° 00′ N., longitude 8° 00′ W., about 130 miles N. NE. from Cape Finisterre. She was reported, in all, twenty-two times, which in itself shows how especially dangerous such a derelict is on the North Atlantic. Drift, 3,525 miles; time, eight months and ten days.

In the preparation of the Pilot Chart every effort is made to collect all possible information regarding such derelicts, drifting buoys, and wreckage of a character likely to constitute a dangerous obstruction; in each case the latest reported position is plotted on the chart, with a line of dashes to indicate the track followed since the first report was received. Thus not only are navigators warned of this source of danger, but important data are being constantly recorded relative to the drift of ocean currents. I may therefore digress a moment to refer briefly to the general features of oceanic circulation in the North Atlantic. The principal factor is, of course, the great warm current known as the Gulf Stream, whose character and limits are so well known as to render it unnecessary now to describe it in detail, and I need only say that it, like all great warm ocean currents, follows very closely the general course of the prevailing winds, to which its existence is very largely due. As has been already pointed out, a noticeably constant area of high barometric pressure exists over the North Atlantic about the Azores and the region to the southwestward of these islands, and the general atmospheric circulation about this area is in a direction with the hands of a watch. To the southward, the prevailing winds are therefore easterly (the well-known northeast trades), while to the northward westerly winds prevail, as is graphically illustrated on the Pilot Chart. Keeping

this great general law of atmospheric circulation clearly before the mind, the general law governing the oceanic circulation follows directly from it. In the region of the trades there is found the great equatorial drift current, a general surface motion carrying the warm waters of the tropics slowly and steadily to the westward into the Caribbean Sea and Gulf of Mexico, whence the greater portion flows in a comparatively narrow and rapidly moving stream to the northward through the Straits of Florida, spreading out and moving more and more slowly as it gets farther north, and finally merging into the broad easterly drift current which flows towards the shores of Europe; here it is again diverted by the influence of land barriers and prevailing winds, and flows partly to the northward along the coast of Ireland and partly to the southward past the coast of Africa. To replace the great volume of water which thus circulates from the tropics toward the polar regions, the cold polar waters flow slowly to the southward, as a rule at the bottom of the sea, but to the eastward of Newfoundland as the cold Labrador current, which brings down icebergs during the spring and summer months and carries them into the track of transatlantic steamships to the southward of Newfoundland; thence it creeps along the Atlantic coast of North America as far south as Hatteras.

Every navigator knows, however, that the surface currents which he has to deal with are subject to many variations from these general laws, due to the temporary influence of the tides and to the effect of strong winds from other directions than those of the prevailing winds; also, that they are greatly modified near the shore by the configuration of the coast. Recent investigations by Lieut. J. E. Pillsbury, U.S.N., commanding the Coast Survey steamer *Blake*, have also developed the important fact that the Gulf Stream is subject to a noticeable and regular influence due to the moon, and that there is a daily variation in velocity, the time of maximum velocity off the south coast of Florida invariably preceding the time of the moon's upper transit by from seven to ten hours; and, moreover, that there is a monthly variation, the maximum in this case being reached two or three days after the time of the moon's greatest declination. These important results have been obtained by anchoring the *Blake* in very deep water, and taking current observations continually by means of an indicator,

which is sent down the wire rope by which the vessel is anchored; thus the velocity can be recorded at any depth desired. These observations are to be continued this winter by the *Blake*, and she will anchor in the equatorial current off the coast of South America and the Windward Islands, in from 100 to as many as 2,500 fathoms of water, a depth of nearly three miles.

A study of back numbers of the Pilot Chart, on which are plotted the latest reported positions and the tracks of derelict vessels and drifting buoys, furnishes an instructive illustration of the general course followed by such obstructions to navigation, as well as the great variations to which these general laws are subject.* Derelict vessels and drifting buoys which first appear near our coast south of Long Island and north of Hatteras, usually drift in a southerly direction, following the inshore current, until they reach Hattaras, where they are driven into the Gulf Stream and there take the direction of the latter. If a derelict be upright, and a northwest or west wind blowing at the time, the vessel will be driven into the stream much sooner than if it were bottom up, or if the winds were variable. The bark *Akbar*, which was wrecked off Savannah, August 27th, drifted up along the coast until it reached Hatteras, while another vessel wrecked a few days later off the Chesapeake, drifted south along the coast till it reached about the same point as the *Akbar*, when both entered the Gulf Stream, there to take the usual northeasterly course. Vessels wrecked between the eastern edge of the Gulf Stream and the Bermudas seem to take no direction in common until they are driven westward and enter the Gulf Stream north of the thirtieth parallel; they circle about for months, influenced mainly by the winds. The most notable case of this kind is that of the schooner *Ida Francis*, wrecked March 16, 1886. This vessel, after crossing and re-crossing its own track a number of times, drifted on the north shore of the island of Abaco, January 6, 1887, nearly ten months later. Similarly, the schooner *Mary E. Douglass*, wrecked August 22, 1887, north of the Bahamas, after circling about for two months drifted ashore at Green Turtle Bay, Abaco, very close to where the *Francis* went ashore. Derelicts abandoned in the "forties" east of the fiftieth meridian are generally carried into northern latitudes

* Illustrated on the screen by means of a lantern slide, showing many notable tracks of derelict vessels.

by the upper branch of the Gulf Stream, or general northeasterly drift current which sweeps the west coast of the British Isles; or else by the other branch to the west coast of Europe, there to enter the Bay of Biscay and the Rennell current, or else to be carried to the southward along the west coast of the Spanish peninsula. A recent and good instance of the northeasterly drift in the Gulf Stream has been furnished by the life raft of the steamship *Manhattan*, which was washed overboard during a hurricane, August 20th, in lat. 30° 50′ N., long. 74° 45′ W. It was reported November 11th, lat. 41° 13′ N., long. 46° 16′ W., having drifted 1,512 miles in two months and twenty-two days, an average of about eighteen and one-half miles a day. The great log raft, when abandoned off Nantucket Shoals on the 18th of December, was directly in the track of transatlantic steamships, and it is good cause for congratulation that it broke up before causing some great disaster. To the student of ocean currents, it will be interesting to watch the tracks which the scattered logs from this great raft will follow, drifting, as they do, under the combined and varying influence of wind, tide and current, and every log offering some slight difference of resistance to each, according to its size, weight, and depth of flotation. To the practical navigator, however, it will be of still greater interest to have logs shipped in the usual way, or at least more securely than was done in this case, in order that dangerous obstructions may not be added in this wholesale manner to those which, in the ordinary course of things, he has to guard against.

By thus following on the chart the drift of derelicts and wreckage they can generally be traced to that part of the ocean lying southwest of the Azores and south of Bermuda; that is, somewhere within the great elliptical area known as the Sargasso Sea, where the currents are slight and variable. Here they circle about for a long time, and either break up or become waterlogged and sink.

Icebergs often get as far south as the fortieth parallel before they melt and disappear. Immersed, as they are, to a great depth, their drift is mainly due to a strong undercurrent. In the same region and at the same time a drifting buoy, which is generally the best indicator of a surface current, would in all probability take a southwesterly direction and follow the Labrador current down the coast; thus a buoy which was reported November 2d, in lat. 46° 20′ N.,

long. 48° 35′ W., was reported December 25th, in lat. 40° 35′ N., long. 69° 15′ W., 900 miles W.SW. from where first reported, an average drift of about seventeen miles a day. Icebergs, however, plow their way into the Gulf Stream to the southward, the difference of direction being partly due to the force of the prevailing winds, but still more to the fact that the cold Labrador current under-runs the Gulf Stream, and by acting on the deeply immersed bergs overcomes the effect of the surface current.

In order to illustrate which months are the ones during which ice is most likely to be encountered off the Grand banks, I have had twelve diagrams (one for each month) prepared in such a way as to be shown together on the screen. On these diagrams the ice reported during each month of the past year is plotted, by means of a conventional sign, in the exact position where each berg or field was reported. It will thus be seen at a glance that February is the month during which icebergs and field-ice begin to be a source of great danger to transatlantic navigation, and this danger continues until the end of August. These diagrams show that, although during January of last year only six reports of ice were received, and these only off St. Johns, Newfoundland, there were plotted on the chart for March more than 100 icebergs and masses of field-ice, reported during the month of February. For this reason the transatlantic routes recommended during the spring months are well to the southward, clear of the probable limit of drifting ice.

This ice consists of field- or floe-ice, which is formed on the surface of the sea during the polar winter, and of icebergs, gigantic masses which break from the glaciers along the coasts of Greenland. With the exception of some field-ice which gets into the Gulf of Newfoundland through the Straits of Belle Isle, this ice is all carried to the southward, past the eastern coast of Newfoundland, and is liable to be encountered off the Grand banks as far south as 40° N. latitude, between the forty-second and fifty-second meridians; indeed, bergs have been reported as far south as the thirty-sixth parallel. A glance at the record of losses and casualities caused by ice last year on the North Atlantic calls attention very forcibly to this class of dangers: several vessels sunk by collision; others caught in heavy field-ice, driven ashore,

or otherwise damaged and delayed; many steamships reaching port with plates stove, rudders carried away, or blades of propeller gone. It is recommended to make free use of the thermometer, although experience shows that too much reliance should not be placed upon it. Experiments made in recent years show that warning may often be obtained by means of the echo thrown back from the surface of an iceberg when a vessel's whistle is sounded, or any sharp noise is made, and apparatus has been invented to utilize the echo to determine the direction and distance of the ice. No possible precaution should be neglected, especially during snow or fog, but the safest course of all is to take a southerly route, well clear of the probable ice limit.

Icebergs have been reported off the Grand banks with a height of more than 200 feet above the surface of the sea, and, from the known depth of flotation of solid ice, such a berg must ground on the Grand banks, there to remain as a new and uncharted island until it dissolves sufficiently to be drifted farther to the southward into the Gulf Stream, where it rapidly melts and disappears. A berg just clearing the bottom of the sea at the 100-fathom curve would have only 100 or 120 feet above the surface; indeed, a solid block of ice is even more deeply immersed. There can be no doubt that the formation of the Grand banks is largely due to masses of sand and soil brought down by icebergs during past ages and deposited where the bergs are melted by the warm waters of the Gulf Stream. Were it not for this great warm current, ice would be a source of danger much farther to the southward. The ice in the North Atlantic during the northern summer cannot be compared either in quantity or size with that brought down from the Antarctic zone into the South Atlantic, between the Falkland Islands and the Cape of Good Hope, during the summer months of the southern hemisphere. Thus one mass of ice which was reported by twenty-one ships from December, 1854, to April, 1855, from 44° S. 28° W., to 40° S. 20° W., was about sixty miles long and forty miles broad, with an elevation above the surface of the sea of fully 300 feet.

I have already referred in the earlier part of my lecture to the fact that supplements to the chart are occasionally issued. With the September chart, for instance, there was issued a supplement

descriptive of West Indian hurricanes, with practical directions for avoiding the dangerous regions of the storm disc, and with the December chart, a supplement descriptive of the winter storm belt of the North Atlantic, with a discussion regarding the best routes for transatlantic navigation.* Such supplements are not issued regularly, but only when some subject of special interest comes up which cannot be discussed or illustrated fully on the Pilot Chart itself. In addition to such occasional supplements, there is issued regularly on Friday of each week what is called the *Weekly Supplement*, a printed bulletin containing brief mention of all late reports of dangers to navigation, changes in lights and buoys, etc., along the Atlantic and Gulf coasts. This publication is intended primarily for the benefit of coasting vessels, and is found very useful, giving, as it does, a digest of all important news received during the week preceding the date of publication. The area covered by this weekly bulletin comprises, roughly speaking, the Gulf of Mexico, Straits of Florida, and that part of the Atlantic north of a great circle from Nassau to the English Channel, and south of a great circle from St. Johns, N. F., to the south of Ireland. From all this area many reports are received less than seven days old. A similar bulletin is published by the branch hydrographic office in San Francisco for the benefit of the coasting trade of the Pacific slope.

I can only refer very briefly to the methods by which reports are collected from masters of vessels, and to do so must first of all refer to the branch hydrographic offices established in six of our principal sea ports—Boston, New York, Philadelphia, Baltimore, New Orleans and San Francisco. It is almost self-evident that upon the efficiency of these branch offices depends, not only the success of the Pilot Chart, but to a large extent the effective working of the entire office. This fact is well attested by the strong support which they have received from the maritime community, and the popularity which they have won among masters of vessels, who can there find all the latest nautical information—charts, light lists, sailing directions—for every ocean of the globe, and standard barometers and thermometers for purposes of comparison.

* A copy of the supplement to the March chart, descriptive of waterspouts off the Atlantic Coast of the United States during January and February, 1888, is issued herewith.

The naval officer in charge of such a branch office, during his three years' tour of shore duty, is thrown into intimate relations with the owners, agents, and especially with the practical and energetic masters of merchant vessels of every description, to mutual advantage, and to the benefit both of the commercial marine and the naval service. Let us consider for a moment the working of the branch office established in the Maritime Exchange, New York, which Lieut. V. L. Cottman, U.S.N., during the few years that he has been in charge, has brought into a position of usefulness commensurate with the vast shipping interests of the great commercial metropolis of the United States: in a single year (1886–87) 6,739 vessels were visited, nautical information furnished to 83,345 masters of vessels and others, 10,397 pilot charts distributed, and 3,601 special detailed reports of marine meteorology forwarded for use in the preparation of the Pilot Chart alone, in addition to all the regular office work, of which this is but a small fraction. Let me illustrate on the screen one of the most important blank forms now issued, on which reports of marine meteorology are recorded.* These blanks are issued in pamphlet form, a year's supply being bound together, and each one is torn out as soon as filled, and forwarded by the first mail that leaves the ship at quarantine; if in a foreign port, it is forwarded by the United States Consul with his official mail. Other special blanks are also issued, but I cannot now refer to them further than to say that they are filled willingly and well on board vessels of every nationality. As soon as received at the branch offices, they are acknowledged and forwarded at once to Washington, to be used, first, in the preparation of the Pilot Chart for the coming month, and then in the compilation of the *Monthly Weather Review* and the *Summary and Review*, issued by the Chief Signal Officer, U.S.A. Thus the Hydrographic Office co-operates with the United States Signal Service by supplying meteorological observations taken at the same instant of absolute time on board vessels in every ocean; by means of such data the isobars and isotherms of the continents of the globe, drawn from data supplied by every nation, can be connected over the intervening oceans and plotted on the daily international chart, just as the corresponding lines are plotted each

* Copies of these forms are issued herewith.

day on the daily weather map of the United States, from observations taken simultaneously at every signal station in the country.* The Signal Service, in return, furnishes from its great store of records such land observations as are needed from time to time to complete data necessary for the thorough study of some great cyclonic storm which has swept the coast, in order that we may learn from the lesson of experience to-day how best to shape our course to-morrow. Thus by earnest mutual co-operation mankind is slowly but surely falsifying the poet's lines—

> "Man marks the earth with ruin—his control
> Stops with the shore"

—and every year adds to the safety of navigation.

There is a widespread but erroneous idea that sailing vessels are being driven from the ocean by steam competition, and that comparatively few are being built: such is far from being the case, and it never *will* be the case. The sailing tonnage of the world is now nearly double that of steam, and this relative proportion is likely to be maintained. The commerce of the United States has had a glorious history in the past, it has survived many years of unfavorable circumstances, and it seems as though we can see the dawn of a new era of prosperity. In the words of Andrew Carnegie: "The shipping of the Republic ranks next to that of the world's carrier, Britain. No other nation approaches her in the race for place. In 1880, the carrying power of Great Britain was 18,000,000 of tons; that of the Republic, 9,000,000, being about one-half the motherland's commercial fleet, but more than that of France, Germany, Norway, Italy and Spain combined, these being the five largest carrying powers of Europe after Britain. The Western Republic has more than five times the carrying capacity of its European sister, France, and quite four times as much as Germany. Her ships earned nearly twenty per cent. of the total shipping earnings of the world in 1880. France and Germany each earned but a shade over five per cent. The first commercially successful steamboat navigated the Hudson, and the first steamship to cross the Atlantic sailed under the American flag from an American port."

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* The daily international chart was illustrated by means of a lantern slide and explained briefly.

With such a history, and with such a standing to-day in spite of the fact that the unprecedented internal development of the United States—agriculture, manufacture, railways—has for a time withdrawn capital and energy from that activity in ship-building and commerce which in the "fifties" was rapidly carrying us to the foremost place, it cannot be doubted that with the awakening of public interest to the need of such a national policy towards our commerce as our conditions and best interests demand, the American flag will again be a familiar sight in every port of the world, in many of which it is now almost unknown. Sir Walter Raleigh well said that "whosoever commands the sea, commands the trade of the world; whosoever commands the trade of the world, commands the riches of the world—consequently the world itself;" now as this is exactly what is, in the opinion of all good Americans, the "manifest destiny" of the United States, we may as well step in now and claim our inheritance, instead of leaving future generations to wonder at our short-sightedness.

In closing this brief review of the wide range of subjects that enter into the preparation of the Pilot Chart, any one of which is worthy the study of a lifetime, I would solicit the interest and kindly feelings of this audience towards the men who pursue the hazardous calling of a seafaring life, and for whose benefit and assistance the work of the Hydrographic Office is so largely devoted. From 5,000 to 6,000 lives are lost at sea each year. Not one of these cyclonic storms, whose tracks I have illustrated to-night, crosses the Atlantic without leaving new derelicts and drifting wrecks in its path, and adding new names to the long list of vessels that have left port never to be heard of more; and what a history of hardship, suffering and death could be written of each of these drifting wrecks, if the whole truth were known! The Hydrographer during the few years of his present tour of duty has succeeded in establishing branch hydrographic offices in our principal sea ports, where nautical information of every character is furnished to navigators free of all expense, and a most appropriate, useful and instructive field of duty offered to naval officers in time of peace. Cordial relations have been established with the mercantile marine, and the machinery of every department of the Government has been utilized to contribute to the safety and success of commerce. The Pilot Chart has been established, to

give early and accurate information regarding the work of each division of the office, and in many ways to lessen the hazards of the sea. In his enforced absence this evening, I feel that I may properly recall to mind that it is to his untiring energy that the perfection of every detail of this work is due. Believing that it is better to honor a man while he is living, rather than to wait for an opportunity to write his epitaph, I cannot close a lecture on the Pilot Chart better than by presenting on the screen the photograph of an old friend of yours, the pilot himself, Commander Bartlett.

THE ELECTRICAL DISTRIBUTION OF TIME.

By ALLAN D. BROWN, Commander, U. S. Navy, Assistant Superintendent of the Naval Observatory, Washington.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *January, 13, 1888.*]

Prof. EDWIN J. HOUSTON, in introducing the lecturer, said:

"The value of any system for the Electric Distribution of Time will necessarily depend on the accuracy of the time transmitted and the extent of the territory covered. I take pleasure in introducing to you Commander ALLAN D. BROWN, of the United States Navy, Assistant Superintendent of the United States Naval Observatory of Washington, D. C., who will explain to you the methods employed by the United States Government for the telegraphic distribution of time."

Commander BROWN spoke as follows:—

The subject upon which I have the honor to address you this evening is the Electrical Distribution of Time. Leaving out of consideration the question as to what Time is, what its measure and how obtained—questions the answers to which would of themselves serve as a subject for an evening's lecture—I will pass at once to a definition of the title which has been chosen for this address. By this title is understood the causing of the instant shown by a timepiece at a central station to be marked by some apparatus prepared to receive the necessary signal at another station in electrical connection with such central station.

If the apparatus at the receiving station is in the nature of a timekeeper, its operation must be automatic; and to secure the highest possible accuracy, the action of the central timepiece must likewise be automatic. In its best form, then, our title may be said to mean the automatic electrical synchronization of one or more clocks by a clock at a central station; with this synchronization may also be associated the registering of the signal upon a chronograph, the ticking of a telegraphic instrument, the firing of a gun, the ringing of a bell, the discharge of a flashing signal, or the dropping of a time ball; in a complete system any or all of these means will be used according to the circumstances of the case under consideration. It is essential, to insure the highest order of accuracy, that the central station shall always be at an astronomical observatory, and preferably at one which is able to devote the services of one or more persons to this special duty. Such work is known briefly as a time service, and its signals as time signals. A brief historical review of the evolution of the time service of to-day will not, it is hoped, prove uninteresting.

As early as 1816, one Ronalds, an Englishman, invented a telegraph which was so dependent upon timepieces for its working that it may be said to have been a device for the temporal distribution of electricity. He connected two clocks with some 500 feet of insulated copper wire; upon the seconds arbor of each clock was placed a circular plate of brass, the circumference of which was divided into twenty equal parts, the chief letters of the alphabet and a double series of numbers up to ten being placed in these divisions. In front of this was a second plate in which was an opening through which one letter and figure were visible; in front of this latter plate was suspended a pith-ball electrometer connected with the wire between the two clocks and also with a frictional electric machine; this apparatus was in duplicate, one for each end of the line. An electrical pistol was also in circuit when the apparatus was not in use, so that by its discharge the attention of the attendant would be attracted when desired. The manner of using this telegraph was as follows: The clocks were first supposed to be accurately synchronized, so that the same letter would appear at the same instant in both plates; the machine was turned and by the electricity thus generated the pistol at the other end of the line was discharged; the attendant in reply made a signal pre-

viously agreed upon, by waiting until this pre-arranged letter was in sight and then turning his machine, when the charge would cause the pith balls of the electrometer to diverge at both stations; the first operator would cause the discharge of the machine by a touch, the pith balls would fall together; the message would then be sent in like manner as each letter came in sight through the hole in the upper plate, the receiver noting each letter as the balls fell. There were two difficulties in the way of the use of this plan; (1) that of obtaining a current at all times; (2) the fact that it would be impossible to keep the two clocks always exactly together; this, however, could easily have been gotten over, as the sender could signal when a certain letter was visible, and the receiver noting the one he saw could then tell how much his clock was out of the way. In effect this was the first attempt at telegraphic time signals, and for this reason only is it here referred to.

In 1833, the German mathematician Gauss, associated with Weber, erected a line of telegraph some five miles in length, connecting the astronomical and magnetic observatories in Göttingen with various other stations. He obtained his current from a crude form of magneto-electric or dynamo machine and the whole apparatus was of a very unwieldy character; a flattened coil containing some 30,000 feet of iron wire had suspended within its centre a magnetized bar weighing some thirty pounds; upon the suspending wire was arranged a mirror in which was reflected a scale, the latter being viewed through a magnifying glass.

The dynamo had a pole changer so that the current could be sent in either a positive or a negative direction, and thus the bar be deflected either to the right or the left at the will of the operator; by a combination of these deflections a message could be spelled out. By this apparatus, as I have gathered, comparisons of clocks were actually made, and to these gentlemen is therefore due the honor of sending the first telegraphic time signals. Although no particulars of the way in which this Time Service was operated are on record, it may easily be surmised that the method was somewhat as follows: probably the hour selected for the signal was noon; two or three minutes before that hour by the standard clock, a signal would be sent over the line; as the hands of the clock marked the exact hour, one distinct deflection

of the bar would be made, at which instant the receiver would note the time shown by his clock; subsequently ascertaining the error of the standard, that of the other would readily be deduced.

In 1840, Mr. Charles Wheatstone announced the invention of an apparatus "enabling a single clock to indicate the same time in as many different places, distant from each other, as might be required." He proposed to accomplish this object by connecting electrically a standard clock with his *electro-magnetic clock*, which latter consisted "simply of a face with its second, minute and hour hands, and of a train of wheels which communicated motive-power from the arbor of the second hand to that of the hour hand in the same manner as in an ordinary clock train;" a small electro-magnet was caused to act upon a peculiarly-constructed wheel placed on the seconds arbor, in such manner that whenever the temporary magnetism was either produced or destroyed, the wheel (and consequently the second hand) advanced the sixtieth part of its revolution. On the axis of the scape wheel of the primary clock was placed a small disc of brass, which was first divided into sixty equal parts; each alternate division was then cut out and filled with wood, so that the circumference consisted of thirty alternations of wood and metal. A very light brass spring was secured to an insulator attached to the clock frame, its free end pressing upon the circumference of the disc; connection having been made between the insulated end of the spring and one end of the wire with which the electro-magnet was wound, the circuit was completed by the other end of the wire being connected to the clock frame through a battery; the primary clock being running, it followed that the circuit was made and broken each alternate second, while the distant dial recorded the advance of its wheel in unison with that of the parent clock. This is practically the same thing as the so-called electric time system of the present day, and it was the first attempt at the distribution of time by electricity. It had the defect common to all such systems of being applicable to only a limited space, and in addition it was subject to the same trouble that besets everyone who proposes to rely upon electricity derived from a battery as a motive-power for any sort of machinery; accidents *will* occur, and in a system of time distribution on this plan an accident is fatal to precision.

The completion of the Morse telegraph between Washington and Baltimore, in May, 1844, afforded the means for the next step in the evolution of our subject, and for this we are indebted to a naval officer, Commander Wilkes (afterward Rear Admiral), who, associated with Lieutenant Eld, transmitted time signals between the two cities. So keen was Wilkes in this matter, and so alive to its importance, that although the telegraph was not completed until the 27th of May, yet, on the 9th of June, Wilkes was exchanging his first signals, completing his work on the 12th. He used two chronometers, each rated to local time, and thus ascertained the difference of time between the two cities, and hence the difference in their longitude; his determination of this difference was only 3-100 second from that subsequently determined by the Coast Survey when more accurate methods had been devised.

Two years later, in October, 1846, time signals were exchanged between the Naval Observatory, in Washington, and the Observatory of the Central High School, in Philadelphia, this being the first use of what has since come to be known as the American telegraphic method of determining differences of longitude. This work was planned under the Coast Survey by Mr. Sears C. Walker, an assistant in that office. The observations were made by Prof. Kendall, in Philadelphia, and Lieutenant Almy, in Washington.

In July and August, 1848, signals were exchanged between the observatory of Harvard College and a private observatory in New York. During this work, Prof. Bond, of Harvard, conceived the idea of an automatic circuit interrupter to be worked by the clock used in the observations. He communicated his ideas to the Superintendent of the Coast Survey, and by him was authorized to construct a clock after his plans. This work was not finished until some time in 1850.

In the meantime Mr. Walker, in conversation with Prof. O. M. Mitchell and Dr. John Locke, of Cincinnati, had told them what the Survey desired in the way of an automatic registration apparatus. Both these gentlemen set at work, and Mitchell devised an apparatus which was finally completed in February, 1849. Locke busied himself in the same direction, and twelve days after his talk with Walker he had perfected his apparatus. In this each of the sixty teeth of a wheel on the seconds arbor of a clock struck the

arm of a tilt hammer. When the tooth was in a horizontal position, the other arm of the hammer fell upon a bed of platinum, which was in connection with one pole of a battery, while the fulcrum on which it moved was in connection with the other pole. The circuit was then broken and made at each rising and falling of the hammer. The next step was to connect the clock with some form of registering apparatus, and for this purpose the ordinary Morse register, with its continuous fillet of paper, was used. On the 17th of November, a little more than three weeks after the idea was first suggested to him, Locke had in operation his clock, registering its beats over the entire line between Cincinnati and Pittsburgh, a distance of more than 400 miles.

This was the first instance in which time signals were delivered *automatically*, by telegraph. As the fillet of paper passed through the register, a continuous record of the seconds was made, with nothing, however, to indicate the beginning of the several minutes; this indication was accomplished by the use of a break circuit key which the observer held in his hand, and pressing at the sixtieth second of each minute, caused the registration to cease for three or five seconds as might be desired, thus marking the beginning of the minutes. Presumably Locke was engaged during the following six weeks in perfecting his invention, for it was not until December 30th that he announced to Lieutenant Maury, the Superintendent of the Naval Observatory, what he had accomplished, and offering it not only for the telegraphic determination of longitudes, but also "as useful in a local observatory as a faithful and convenient register of observations" On the 5th of January, 1849, Maury replied in substance as follows: "I regard it as one of the most important inventions of the age. Feelings of professional pride give additional zest and warmth to these congratulations. For ages the problem of longitude has occupied the mind of wise men, and commanded the attention of governments. This discovery of yours is the crowning work in the great problem. Permit me to claim this high honor first for my country, and next for the navy. An American naval officer, Capt. Wilkes, was the first to apply the magnetic telegraph to the practical determination of longitude. It greatly lessened labor and refined results. The next and last step has been made by yourself, who also are an ex-officer of the navy. You have, by your invention, eliminated

from the problem the errors arising from comparing the face of one clock with that of another, and made it as easy and practicable to divide seconds into hundredths, as before it was to divide minutes into seconds. By your invention you enable the astronomer to make the ticks of his clock here in Washington to be heard wherever the telegraph leads, and you make the clock to divide those seconds into hundredths."

On the same day he addressed a letter to the Secretary of the Navy informing him of Locke's invention and recommending it in the highest terms. This letter was made public, and after some further correspondence it was followed by an invitation from the Secretary to Locke to come to Washington; the subject of an appropriation was discussed, and after much push on Maury's part the sum of $10,000 was put in the naval bill by the House, for the purchase of a clock on Locke's plan; this came very near being lost in the Senate, but it was saved by the exertions of the friends of the measure, and became a law on the 3d of March. By the provisions of the act the clock was to be erected at the Naval Observatory. This was done, and on the 7th of December, 1849, the clock, with the chronograph attachment was used, for the first time, and proved to be a great advance over the old method, although there was still some difficulty in the matter of accurate registration.

As before stated, in 1850, Prof. Bond, of Harvard Observatory, completed his clock for the Coast Survey, and in addition invented an improved chronograph in which the paper was placed upon a revolving cylinder, the driving power of which was so adjusted as to cause one revolution per minute to be made, the record being made by a pen in a continuous spiral line; but as in Locke's plan of the Morse fillet, there was no means of noting the beginning of each minute automatically. About the same time the cylindrical form was under consideration at Washington, but there were some difficulties which it does not appear were surmounted at this date.

In 1851, the Bond chronograph, with its ingenious driving machinery known as the spring governor, was taken to England and there exhibited, eliciting much commendation and receiving a gold medal at the Great Exhibition of that year. The Astronomer Royal, of the Greenwich Observatory, in his report for June, 1851,

states that he has adopted the plan of "making a galvanic register of transits in the American manner," but the cylindrical chronograph was not adopted until some three years later—a suggestion by Maury during a visit to Greenwich having enabled Sir George Airy to overcome the practical difficulties which were encountered.

During this same year, the observatory at Harvard was connected with the various telegraph lines from Boston, as many longitude operations were being carried on for the Coast Survey. In this manner the attention of such portion of the public as were interested in such matters was drawn to the practicability of obtaining accurate time from the observatory, and in many cases regular arrangements were made for the transmission of the signals throughout Massachusetts and some of the other New England States. Indeed, at present, the time service of Cambridge furnishes the chief source of comparison in that section of the country; the observatory of Yale College also possesses such a service, which supplies Connecticut in like manner. The observatory of the Washington University at St. Louis, and that at Alleghany, Pa., also have extensive time service; and there are others covering less ground.

At Washington the Naval Observatory has dropped a time ball since the first occupation of the completed buildings in 1844, following the example set at Greenwich, eleven years earlier. At first the dropping was done by hand, upon signal received from the chronometer room; later this signal was sent electrically and the dropping of the ball was performed automatically by the same signal. This ball served to give the moment of noon not only to the cities of Washington and Georgetown, but also to the Navy Yard and to such vessels as happened to be lying there. No telegraphic signals were transmitted, however, for several years, the Royal Observatory at Greenwich far outstripping us in that respect, as a system of time signals to the important cities and towns of England was in operation as early as 1852. This, of course, was readily accomplished in a country of such small extent, where the difference of any given local time from that of Greenwich is not great; but in our own case, the great extent of longitude and the different local times kept through what was supposed to be the necessity of the case, conspired to prevent the extension of any such

system. Local jealousies had also a part to play in the matter, as the railroads running out of Boston would not keep New York time, and *vice versa*

With this brief retrospect of the course of events which has made the electrical distribution of time possible, let us return to the subject proper of this essay; and in so doing I beg leave to repeat a portion of the definition with which it began, viz: "By the electrical distribution of time is understood the causing of the instant shown by a timepiece at a central station to be marked by some apparatus prepared to receive the necessary signal at another station in electrical connection with such central station. It is essential, to secure the highest order of accuracy, that the central station shall always be at an astronomical observatory, and preferably one which is able to devote the services of one or more persons to this special duty." In order to a fuller understanding of the functions of an observatory, it will be necessary to call your attention to some of your early instruction in astronomy. The interval between two successive transits, or meridian passages, of the sun, is an apparent solar day; owing to the unequal motion of the earth in its orbit (or to put the statement in another form, to the apparent unequal motion of the sun in the ecliptic) two successive apparent days are not of the same length. As a constant standard of time is necessary, it has been found essential to assume an imaginary sun moving in the equinoctial (or the plane of the earth's equator) at a uniform rate, which is the mean rate at which the true sun moves in the ecliptic; the interval between two successive transits of this imaginary mean sun is a mean solar day, and in a clock keeping mean time, the hands would (if the clock were correct) point to $12^h\ 0^m\ 0^s$ at the instant of transit, which is known ordinarily as NOON. As a matter of fact, however, the sun is rarely used at observatories for the determination of time, but stars are employed instead; this is done, not only because the tables of the positions of the stars are more accurate, but because several stars can be observed at about the same time and the results deduced from these observations made to serve as checks upon each other. The interval between two successive transits of the same star is called a sidereal day; this interval is constant, and is (like the mean solar day) divided into twenty-four hours. Each star comes to the meridian at an earlier period than on the day preceding, if

the transit be noted by a mean time clock; the difference between a star and a sidereal day is $3^m\ 56^s\ 56$, and hence the sidereal 0^h is constantly getting ahead of the solar 0^h, so that it is always necessary to reduce the *sidereal* time found by the star observations to that used in ordinary life, or to *mean* time. The positions of stars are given in the tables by their *declination* (similar to terrestrial latitude) and their *right ascension* (similar to terrestrial longitude); the right ascension of the star being reckoned from the celestial prime meridian, it follows that when any given star crosses the meridian, the sidereal clock should show the time given in the table as the right ascension of such star; the difference between the time actually shown by the clock and this right ascension is the error of the clock; comparing then the time shown by the sidereal clock with that shown by the mean time clock, we find the error of the latter. This is briefly the method followed by all observers, and hence is common to all systems of time signals. We have, then, as essentials of any such system, (1) an instrument for observing the transits of stars; (2) a sidereal clock, and (3) a mean time clock. This mean time clock (like all timepieces) will not run accurately, its rate varying, being sometimes less and sometimes greater; the pendulums of such clocks are generally very well compensated for changes of temperature, but it has been found that the density of the air has a decided influence upon the rate at which the clock runs; when the barometer is high, the clock loses on its rate, gaining when it is low. In order, then, that the time which is sent out over the wires should be correct, it is necessary either to have some arrangement for correcting the standard mean time clock so as to make it correct, or else to have a similar clock which can be likewise corrected; such a clock is known as a transmitter.

The system of the Greenwich Observatory being the oldest in point of time merits the first description. The standard sidereal clock is a remarkably fine piece of workmanship, having in addition to a peculiarly constructed compensated pendulum, an auxiliary apparatus intended to still further aid in the compensation for changes in temperature, which it would be impossible to describe intelligibly without a drawing. There is also an arrangement for counteracting the influence of the variations in the density of the air, which is the invention of Sir George Airy, and

is very ingenious; two bar magnets are secured to the bob of the pendulum diametrically opposite each other, one with the north pole down, the other with same pole up; below these at a distance of about four inches is a horseshoe magnet which hangs on one end of a walking-beam, to the other end of which is attached a float resting on the surface of the mercury in the cistern of a specially-constructed barometer; with a rise in the barometer the horseshoe magnet rises nearer the bob and thus exerts a stronger influence upon the swinging magnets, causing the pendulum to oscillate more rapidly; the contrary takes place when the mercury falls. Notwithstanding all these refinements the published records of the observatory show that the clock does not run with perfect accuracy, a variation of its daily rate as large as 1·15 seconds being recorded in a year. It does, however, run with but slight variations of rate from day to day; still it shows as great a loss as one minute in six months; it is supposed to be regulated to lose a small amount daily, but the records show that it occasionally gains as much as half a minute in five or six months. I mention this here in order to show you that those people who talk about their clocks or watches running to within a few seconds a year are probably somewhat wide of the truth. This standard sidereal clock registers its beats upon the chronograph used in observing transits, controls the remaining sidereal clocks in different rooms of the building and finally drives (in unison with itself) a sidereal chronometer. The controlled clocks are upon the Jones' system (as modified by Sir George Airy); in this system the secondary clocks are required to be quite as good time-keepers as the primary one, which makes it too expensive for general use among the public. As used at Greenwich, the standard clock closes a circuit in which the controlled clocks are placed, every second; on the pendulum of each of these latter is a magnet, which at the end of its swing enters a coil of insulated wire; as the current passes the effect is to hold the magnet within the coil, and hence to place the pendulum in a definite position, which corresponds in effect to that of the pendulum of the primary clock; this closes the circuit by means of a wheel on the seconds arbor, which presses upon a spring at each forward motion. The sidereal chronometer already spoken of in this connection, is constructed practically upon the same principle as those of Wheat-

stone, referred to in the early part of these remarks. This sidereal chronometer is in the time service room and is used for the purpose of comparison with a similarly-constructed mean time chronometer which is driven by the mean time clock now to be described; this is essentially a galvanic clock of peculiar construction, and of which I imagine there are but few existing; as the pendulum swings to the right it closes a circuit through the coils of an electro-magnet which actuates a peculiar mechanism, by which, as the pendulum swings to the left, a weight is caused to impinge upon the pendulum, thus giving it the impulse which in an ordinary going clock it receives from the weight or spring; this impulse is given at each alternate vibration. At each extremity of the swing of the pendulum it closes a circuit which, acting upon the coils of two electro-magnets, alternately attracts and repels the opposite ends of a balanced polarized armature; this rocking motion is readily converted into a rotary one, causing the seconds hand to revolve, and, by the usual device of a train of wheels, the minute and hour hands also; there are several clocks driven by this pendulum, including the mean time chronometer just mentioned as being in the time service room. The apparatus for correcting the error of the standard mean time clock consists of a magnet secured to the pendulum which swings over a hollow coil of insulated wire attached to the clock case; if a current be passed through the coil in one direction the magnet on the pendulum is attracted and the oscillations are more rapid; if a current be sent in the opposite direction the contrary is the case; a switch in the time service room serves to operate this arrangement when desired, and the battery is so arranged that it will accelerate or retard the pendulum at the rate of one-tenth of a second in a minute. The practical working of the observatory portion of the time service is as follows: The error of the standard sidereal clock is obtained by means of star observations as before described; at 9 A. M. daily, the mean time and sidereal chronometers in the time service room are compared by what is known as the eye and ear method; that is to say, the observer waits for the coincidence of the beats of the two instruments and notes the time shown by each at this instant; applying the error of the sidereal clock to the time shown by the sidereal chronometer, the correct sidereal

time is found; by a comparatively simple operation the corresponding mean time is found, and from this the error of the mean time chronometer, or what is the same thing, the error of the standard mean time clock; suppose that this clock is found to be one second slow; the switch to the coil in the clock is turned in the accelerating direction for ten minutes, during which time the pendulum is swinging faster than usual, and at the end of this period the clock has gained the necessary second; and not only the standard, but all the clocks that are driven by it. In this condition the standard is in readiness to be used as a transmitter; it is in a circuit which is closed automatically every hour by the operation of wheels within the clock itself. The closing of this circuit operates a relay which transmits a single beat (that of 0 minutes and 0 seconds of the exact hour), to the General Post-Office in London, and also to the station of the railway leading to Deal. At this latter point a time ball is erected and is dropped by the hourly signal sent at 1 P.M. The hourly signal is also transmitted over certain private wires belonging to various jewelers, for the purpose of comparing their timepieces. In one case, at least, this signal is also used for purposes of distribution, as will be noted further on. The line to Deal is for a short time virtually under the control of the observatory, so that a return signal is sent which announces the fall of the ball. A very ingenious adaptation of the galvanic clock described as the mean time standard is in use on this circuit. At a certain point where the line to Deal is looped in, this second clock is placed. It is regulated so as to have a gaining rate of several seconds, so that at 1 P.M. it is always too fast. When that hour is shown by the clock, the circuit which operates the electro-magnet and thence the clock train is switched out automatically, and the Deal loop is switched in, the pendulum continues to swing until the passage of the signal from the observatory opens the circuit and the clock then moves on, showing the exact Greenwich time as it starts.

(*To be continued.*)

On SOME EARLY FORMS of ELECTRIC FURNACES.

No. 7. SIEMENS' ELECTRIC FURNACE or CRUCIBLE.

By Prof. Edwin J. Houston.

In 1879, Charles William Siemens took out letters-patent in Great Britain for "Improved Means and Apparatus for Producing Light and Heat by Electricity." This patent is numbered 2110 of 1879. The completed specification is dated November 26, 1879.

The matter contained in this patent, is, to some extent, an application of the principle described in a prior patent, No. 4208 of 1878, to the same inventor. This principle consists briefly, in cooling one of the electrodes of an electric source, by means of a stream of water forced through a cavity in the same.

Siemens applies this principle to the utilization of the direct heat of the voltaic arc for the heating of a crucible, in which furnace operations that require great heat may be conveniently carried on.

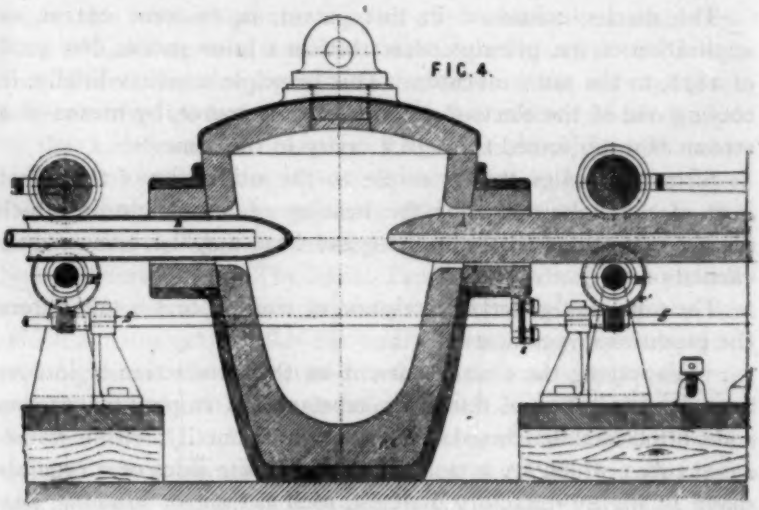
The following general description of this process is taken from the provisional specification, viz:

"In applying the electric current to the production of intense heat for the fusion of refractory substances, I employ two carbon rods, fitted to slide towards each other horizontally, within water-cased tubes, which are attached to the opposite sides of a crucible made of highly refractory material, such as lime or alumina, also water-cased if necessary. The substance to be fused is introduced into the crucible, and the carbon rods are advanced sufficiently near to each other to form the voltaic arc within the crucible. The clockwork which advances them has a flyer which can be retarded or arrested by a brake or stop connected to a thin metal strip which forms a part of the electric circuit, or to the armature of an electro-magnet, the coil of which forms part of the circuit. As the heat in the crucible increases, the resistance to the voltaic arc within it diminishes, and consequently the arc can be elongated, a result which results from the automatic retardation or stoppage of the feeding clockwork. The crucible may be closed by a cover

having apertures through which air or other gases may be blown or drawn to act on the substance under treatment. In some cases, instead of employing carbon for the terminals, they may be made of the material that is to be fused, when it has sufficient conductivity."

It will be noticed that the electric furnace of Siemens does not differ, in its essential features, from the earlier forms described by Depretz in connection with his experiments on the fusion of refractory substances, except that in some of Depretz's forms the voltaic arc did not play directly on the material subjected to fusion, but heated to intense incandescence the carbon crucible or vessel in

FIG. 4.



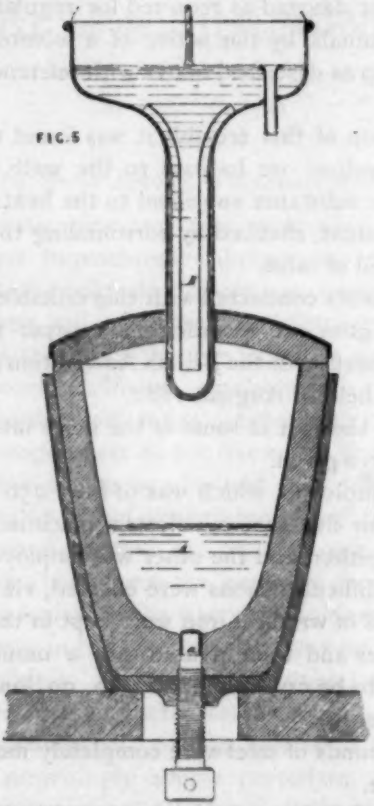
which said substance was placed. Depretz's furnace, however, provided no means for cooling the ends of the electrodes.

Siemens' furnace was not merely a crucible in which the fusion of highly refractory substances was accomplished. The hollow carbons, or the perforated cover, provided for the introduction of air or other gas, clearly shows that he contemplated the carrying on of what might properly be classed as furnace operations, or reductions, under the influence of the high temperature of the voltaic arc.

The forms of electric crucibles devised by Siemens will be best understood from the following description taken from the com-

pleted specifications, viz: "*Fig. 4* shows apparatus according to my invention for applying the heat of the voltaic arc within a crucible." * * * "I have shewn in the Figure one of the terminals *A*, to be a carbon, and the other *B*, as a metal pole cooled by circulation of water as described in the specification above referred to. Both terminals might, however, be carbons, and both

FIG. 5



or either might be tubular, as shown with respect to *A*, so that currents of air or other gas might be sent through them into the crucible for effecting chemical reactions therein. The terminals rest on grooved rollers *R*, *R*, being pressed down thereon by heavy rollers *r*, *r*." * * * * * *

"When the material treated in the crucible is a conductor, the arrangement shown in *Fig. 5*, may be adopted. In this connection

material *A*, such as fused metal forming the one terminal, lies in the bottom of the crucible in contact with a screw or pin, *a*, faced with the platinum or other metal that will not be acted on by the material *A*. The other terminal *B*, which is cooled by the passage of water through it, as described in the specification above referred to, is suspended through a hole in the crucible cover, and it can be made to ascend or descend as required for regulating the distance between the terminals, by the action of a solenoid or expanding metal wire or strip as described above with reference to the carbons of electric lamps."

In the operation of this crucible it was found that there was a tendency of the voltaic arc to pass to the walls of the crucible, rather than to the substance subjected to the heat. This tendency was, to a great extent, checked by surrounding the outside of the crucible with a coil of wire.

Some experiments conducted with this crucible by Dr. Siemens and Prof. Huntington, are recorded in a paper read by them at the fifty-second meeting of the British Association for the Advancement of Science, held in August, 1882.

The following abstract of some of the more interesting of these experiments is here given.

The current employed, which was of from 250 to 300 ampères, was obtained from five dynamo-electric machines, four of which were coupled together, and the other was employed as an exciter.

A number of difficult fusions were effected, viz:

(1) Six pounds of wrought iron were kept in the heat of the arc for twenty minutes and then poured into a mould. The cooled metal was found to be crystalline and to no longer possess the ability to be wrought.

(2) Twenty pounds of steel were completely melted in one hour in a single charge.

(3) Three-fourths of a pound of copper, placed in carbon dust, were melted in half an hour—only three-fourths of an ounce, however, was found remaining in the retort. The rest had been vaporized!

(4) One-quarter of an hour was sufficient to reduce eight pounds of platinum to the liquid state.

(5) Some curious results are noticed both during the fusion and vaporization of tungsten, and in the properties of the product as found in the electric crucible.

The electric crucible, as constructed by Dr. Siemens, must be regarded as admirably suited for investigation on the fusion of refractory substances.

CENTRAL HIGH SCHOOL,
PHILADELPHIA, *April 5, 1888.*

CHLOROPHYL AND GELATINE-BROMIDE PLATES.

BY FRED. E. IVES.

[*Read at the Stated Meeting, Wednesday, April 18, 1888.*]

The isochromatic processes now most used are incapable of producing correct monochrome photographs of objects in all colors; eosine and erythrosine plates are insensitive to red, and even cyanine plates will not show any difference between a black and a deep red without greatly over-exposing orange and yellow. The original process (collodion emulsion with chlorophyl) is the only one yet published which has not this defect.

But most photographers do not like to use this process, because suitable chlorophyl cannot be procured at all times, nor preserved without considerable loss of sensitiveness, and the plates must be prepared immediately before use, and exposed wet, in a strong light. Many who have seen the beautiful results obtained with this process have lamented the fact that chlorophyl could not be applied successfully in the gelatine plate process, and I tried many times to accomplish it. On several occasions, I obtained considerable color-sensitiveness, but the result was so uncertain as to be puzzling and discouraging. At last, however, I have succeeded in securing, by a surprisingly simple procedure, the full action of chlorophyl upon commercial gelatine-bromide plates.

The degree of color-sensitiveness obtained appears to bear a definite relation to the general sensitiveness of the plate employed, which should, therefore, be of the most rapid kind. They are prepared by flowing with the alcoholic solution of chlorophyl, *then drying* rapidly, *then soaking in water* for at least five minutes, after which they may be used at once. With two-year-old chlorophyl (obtained from suitable leaves, at the proper season, and

preserved with zinc powder in the solution), the absolute color-sensitiveness is fully equal to that of commercial "orthochromatic" plates, and is so distributed as to be capable of giving far more accurate results; but the blue-sensitiveness, which is reduced by cyanine and erythrosine, is actually increased by chlorophyl, making it necessary to use an extra deep orange color-screen with these plates. This excessive blue-sensitiveness is, in fact, something of an objection to the plates, because it is not easy to get a color-screen that cuts off just the right amount of blue light. With screen and exposure that would be exactly right for the commercial "orthochromatic" plate, the chlorophyl plate would be far over-exposed, with five or ten times too much action in the blue and violet. But if the color-screen is deep enough, the resulting negative is perfect for all colors.

For purpose of comparison, I have made one photograph of the solar spectrum on a very rapid gelatine-bromide plate treated with chlorophyl, and another on a commercial "orthochromatic" plate. A yellow screen was used to reduce the action at the violet end of the spectrum, and both plates received the same exposure. The total amount of action below the Fraunhofer line *E* is about the same in both plates, but in the commercial "orthochromatic" it is mostly confined to the yellow, while in the chlorophyl plate it is pretty evenly distributed throughout the yellow-green, yellow, orange and red, down to the Fraunhofer line *a*.

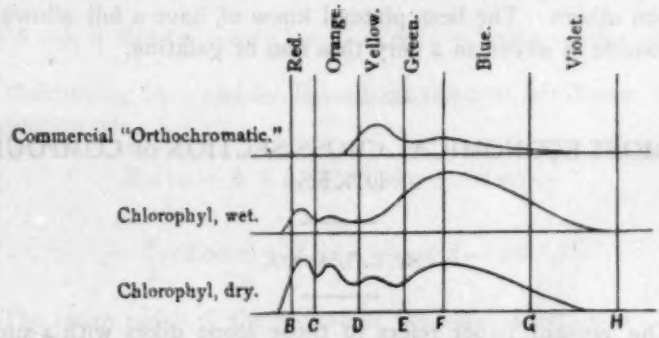
In view of the fact that chlorophyl has been tried with gelatine-bromide plates a great many times, and in various ways, without definite success, the most surprising thing about this method is its simplicity.

Since obtaining these results, I have read a very interesting paper by Capt. Abney, in which he calls attention to the fact that cyanine and erythrosine will impart color-sensitiveness to a commercial gelatine-bromide plate when merely applied to the surface, as by flowing the plate with collodion or varnish in which a little of the dye is dissolved. He concludes that contact of the dye with the surface molecules of bromide of silver in the plate is all that is required to secure color-sensitiveness, and suggests that chlorophyl should therefore succeed with gelatine-bromide plates if merely applied in that way, or in alcoholic solution. It

will not; the subsequent soaking in water is essential to the production of color-sensitiveness.

LATER EXPERIMENTS.

Since the above paper was read, exposures have been made upon dried plates, with the following results: The color-sensitiveness proved to be about three times greater than before drying, and the blue sensitiveness considerably less. The dried plates invariably fogged, and it was necessary to use a brush to prevent the formation of air bells and force an even action of the developer.



Action of solar spectrum on commercial orthochromatic and two-year-old-chlorophyl gelatine-bromide plates, through light yellow color-screen.

EXPERIMENTS WITH ERYTHROSINE AND CYANINE.

The discovery that chlorophyl would act so well when applied in the above-described manner, suggested the idea of trying other color-sensitizers in the same way. Plates were therefore prepared with erythrosine, by flowing with alcoholic solution,* then drying, then washing or soaking in water. The result was a great surprise. Although not a trace of ammonia or silver were used, the plates showed several times more absolute color-sensitiveness than the dried chlorophyl plates (but all in the yellow and green), and about ten times more than the commercial orthochromatic plates. They work clear and brilliant, and are sensitive enough for portrait work with the yellow screen.

Cyanine was then tried in the same way, and gave even more remarkable results than erythrosine. Without reducing the blue sensitiveness in the least, it made an extra rapid plate as sensitive

* Erythrosine, 1 gr.; alcohol, 4 oz.

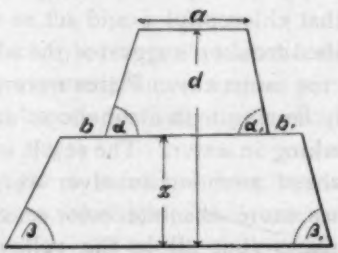
to the orange-red, orange and yellow of the spectrum as to the blue, and as sensitive to the green as to the violet. The absolute color-sensitiveness is many times greater than was ever before produced by cyanine, and ten times greater than has been produced by chlorophyl. The first plates that were prepared in this way gave only a mass of fog; the successful plates were washed and developed in total darkness.

One very important fact, discovered in the course of these experiments, is that the action of the dyes, by whatever method applied, is at least three times greater on some commercial plates than on others. The best plates I know of, have a full allowance of bromide of silver, in a very thin film of gelatine.

THE MOST ECONOMICAL CROSS-SECTION OF COMPOUND DIKES.

BY L. D'AURIA.

[The present paper refers to those stone dikes with a superstructure of concrete or crib work. The problem which the paper implies was proposed to the writer by Mr. L. Y. Schermerhorn, C.E.]



Let a represent the width at the top of the superstructure; b and b_1 the width of the bermes left at one side and the other of the foundation; d the total height of the section of the dike; α and α_1 the inclinations of the sides of the superstructure, and β and β_1 the inclinations of the sides of the foundation with the horizon; A, the cost per cubic foot of superstructure, and B, the cost per cubic foot of foundation.

The problem which is proposed to solve, consists in determining the height x of the foundation in manner, so that the cost of the dike will be a minimum.

The width at the top of the foundation is evidently

$$a + b + b_1 + (d - x)(\cot a + \cot a_1),$$

and the width at the bottom of the foundation is

$$a + b + b_1 + (d - x)(\cot a + \cot a_1) + x(\cot \beta + \cot \beta_1).$$

Taking one-half of the sum of the two, we obtain the mean width of the foundation, viz:

$$a + b + b_1 + d(\cot a + \cot a_1) - \frac{x}{2}(2\cot a + 2\cot a_1 - \cot \beta - \cot \beta_1).$$

Multiplying by x and by B, we have the cost per linear foot of foundation, viz:

$$B x \left[a + b + b_1 + d(\cot a + \cot a_1) - \right.$$

$$\left. - \frac{x}{2}(2\cot a + 2\cot a_1 - \cot \beta - \cot \beta_1) \right].$$

The mean width of the section of the superstructure is

$$a + \frac{d - x}{2}(\cot a + \cot a_1),$$

which, multiplied by $(d - x)$ and A, gives the cost per linear foot of superstructure, viz:

$$A(d - x)\left[a + \frac{d - x}{2}(\cot a + \cot a_1) \right].$$

Adding this to the cost per linear foot of foundation, and putting equal to zero the first *derivate* of the sum with respect to x, we find

$$x = \frac{(A - B)[a + d(\cot a + \cot a_1)] - B(b + b_1)}{B(\cot \beta + \cot \beta_1) - (2B - A)(\cot a + \cot a_1)}.$$

Putting $\frac{A}{B} = n$, will be found

$$x = \frac{(n - 1)[a + d(\cot a + \cot a_1)] - (b + b_1)}{\cot \beta + \cot \beta_1 - (2 - n)(\cot a + \cot a_1)}.$$

When the superstructure is rectangular, as in the case of cribs,

then $\cot \alpha = \cot \alpha_1 = o$, and

$$x = \frac{a(n-1)-(b+b_1)}{\cot \beta + \cot \beta_1};$$

and when the bermes are equal and $\beta = \beta_1 = 45°$, then

$$x = \frac{1}{2} a n - \frac{a+2b}{2} \quad (1)$$

In the report of the Chief of Engineers of the U. S. Army, of 1887, p. 2407, Major M. B. Adams, with a direct analysis applied to this last case, finds,

$$= \frac{c}{2 l c^1} - \frac{a+2b}{2} \quad (2)$$

in which c is the cost of one hemlock course and its stone filling above grillage, whose length is l, and c^1 is the cost of one cubic foot of foundation. Now, observing that $c = A a l$ (in which A is the cost per cubic foot of crib), and that $A \div c^1 = n$, equations (1) and (2), after the substitution, will be found to be identical.

Since $a + 2b$ represents the width at the top of foundation, we can denote this width by f, and write

$$x = \frac{1}{2}(a n - f),$$

which is very simple to remember and can be applied readily as a test to dikes already built.

GENERAL THEORY OF JOINTED BOW GIRDERS.

By E. A. Werner, C.E.

(*Continued from Vol. cxxv, page 409.*)

ERRATA.

Note.—Correct in Part I, of this paper, the following errors:

Page 391, line 7 from top, *read*—

$$V_m = Q - G_1 \text{ instead of } V_m = Q - g_1$$

Page 394, *read* equation 12—

$$\frac{2fx + ly}{2fl} = \frac{\zeta + y}{2f} \text{ instead of } b = \frac{2fx + ly}{2fl} = \frac{\zeta + y}{2f}$$

Page 396, line 13 from top, *read*—

$$\zeta \gtrless y \text{ instead of } \zeta \lessgtr y$$

the reactions of the abutments.

These equations give the internal forces of the removed part as functions of the external forces, which have been developed in the first part.

The above equations express quite generally the conditions, which must be fulfilled in any structure, regardless of form, system, loading, or number of supports used.

As there are only *three* equations we deduct, that, without more or less arbitrary assumptions, not more than three unknown quantities or forces can be defined in any section of a structure.

The structures intended to resist the forces represented by the above equations must be able to take up horizontal and vertical

then $\cot a = \cot a_1 = o$, and

$$x = \frac{a(n-1)-(b+b_1)}{\cot \beta + \cot \beta_1};$$

and when the bermes are equal and $\beta = \beta_1 = 45°$, then

$$x = \frac{1}{2} a n - \frac{a+2b}{2} \quad (1)$$

In the report of the Chief of Engineers of the U. S. Army, of 1887, p. 2407, Major M. B. Adams, with a direct analysis applied to this last case, finds,

GENERAL THEORY OF JOINTED BOW GIRDERS.

By E. A. Werner, C.E.

(*Continued from Vol. cxxv, page 409.*)

PART II.—INTERNAL FORCES OR STRAINS.

A.

LATTICE GIRDERS.

As we know from the first part, the equations expressing the equilibrium of the forces in the structure are those of a free, rigid system, or if we refer the system to a rectangular system of co-ordinates:

$$\Sigma(x) - H = o$$
$$\Sigma(y) - V = o$$
$$\Sigma(x\,y) - M = o$$

wherein:

$\Sigma(x)$, $\Sigma(y)$, $\Sigma(x\,y)$ represent the sums of all the forces in the direction of the X and Y axis and their moments, H, V, M, the same sums with regard to the external forces—the loads and the reactions of the abutments.

These equations give the internal forces of the removed part as functions of the external forces, which have been developed in the first part.

The above equations express quite generally the conditions, which must be fulfilled in any structure, regardless of form, system, loading, or number of supports used.

As there are only *three* equations we deduct, that, without more or less arbitrary assumptions, not more than three unknown quantities or forces can be defined in any section of a structure.

The structures intended to resist the forces represented by the above equations must be able to take up horizontal and vertical

forces and their moments,* and if we remember, that a moment can be taken up in its plane at any point, the same as the point of application of a force can lie in any point in the direction of the force, we see that the stiffening structure, as is called the structure taking up the effect of the moments, can lie anywhere in the bow girder and that a great variety of forms and systems will come under the above equations.

Accordingly as a separate stiffening structure is used or not, we shall have:

(1) A *slack* bow, the stiffening structure forming a separate structure or truss.

(2) A *stiffened* bow, the stiffening structure being connected with the bow struts.

NOTE.—Generally a subdivision of the stiffened bow is called "stiffened gusset," when the stiffening structure fills the gusset between the bow and the road.

Still as the way to take up the moments is completely arbitrary, we can as well use two or more stiffening structures and have thus a *third* great subdivision:

(3) Partially stiffened bow and partially stiffened roads. The stiffening is then scattered over the bow struts and a special stiffening structure.

Moreover, any bow can be used as a "beam" having *only* vertical and *no* horizontal reactions, by tying together both abutment joints with a string taking up the horizontal thrust of the abutments. We have then:

(4) The *bow beam*, and any one of the above systems may be used in the bow beam.

But if the stiffening structure is connected with the string, some more very useful combinations are brought forth. They are called *bow beams with stiffened strings*, and comprise the following combinations:

(1) The string forming the lower chord of the stiffening structure.

(2) The string forming the upper cord of the stiffening structure.

* As is known, the faculty to take up horizontal forces is the deciding characteristic of bow structures, but not every structure taking up horizontal forces is a bow structure, as we shall see later.

In both cases, if the bow structure has only negative or positive moments, the stiffening structure can have *two* tension chords and no compression chord, provided the stiffening structure is so disposed as to have the strains from the thrust in the respective chord of the stiffening structure greater always than the compression strain from the moments.

(3) The stiffening filling the space between the string and the bow strut.

These structures look much like ordinary beams, having only joints on top. These are the most used forms of the bow structures. Other variations may yet be found in combining the above forms, but howsoever this may be done, the structure will consist either of *separate parts* taking up separately the horizontal and vertical forces and moments, or of *one* structure taking up all the forces at once, and accordingly as the first or second arrangement is selected the expression of the forces acting in the members will be different. But whether we select a structure with separate stiffening girder, or a stiffened bow structure, in applying the general equations of equilibrium to it, the resulting expressions will contain besides known quantities on one side:

[the strains in the members] on the other [$y_m^0\ y_m'\ y_m''$] the quantities expressing the form of the structure and, accordingly as one or the other of these groups of quantities is assumed to be known, we shall have *two* quite different problems to solve:

I. The form of the structure being given, to find as functions of the external forces (loads and abutment reactions).

(1) The forces acting in the members; and,

(2) The maximal and minimal values of these strains and the rules governing them.

II. The forces (strains) in the members of the structure with their maximal and minimal values being known, also the laws governing them, to determine the form of the structure so as to answer certain special conditions.

The solution of problem II gives the means on hand, by using special appropriated forms, to keep the values of the strains acting in certain members inside of certain limits, or to alter to a certain extent the laws governing these strains, but this problem II can evidently not be solved without the knowledge of the strains expressed as functions of the loads and the rules governing the maximal and minimal values of these strains.

I thus begin with the first problem:

I. *The form of the structure being known, to find:*

(1) *The strains in the members as functions of the external forces.*

(2) *The maximal and minimal values of these strains and the positions of the loads inducing them.*

In this case $y_m^0\ y_m'\ y_m''$ are known quantities, the figure of the structure being given *a priori.*

The structures themselves can consist, regardless of form or system, of:

I. Structures with open web (lattice).

II. Structures with full web (plate), and this so, that either one kind, or in case of several parts forming the bow, both kinds combined, are acting and the way of developing the equations, expressing the forces acting in the different parts, will necessarily be different accordingly as lattice or plate girders are selected.

I will begin in developing the equations, when the structure consists of:

LATTICE GIRDERS.

In these girders, in opposition to girders with full web, the material is massed in single members.

In these girders it is always assumed:

(1) That the deformation of the whole system is so slight, that it can be neglected, especially so slight that the length of the members and the angles between them are not materially affected.

(2) That the resultings of the forces of the different members intersect *mathematically* in points, the *panel points.*

(3) That the loads are taken up in the panel points.

(4) That the exact length of h = depth of the stiffening truss is used.

This depth is as known:

$$h = \frac{\text{Moment of Inertia}}{\text{Statical Moment}} \text{ of the section.}$$

If these assumptions are not mathematically fulfilled, supplementary strains will be generated in the members, of which the following theory gives no account and which will greatly alter the result or even make it completely wrong.

In lattice girders evidently the longitudinal members must take

up the thrust. But the way this is done is completely arbitrary. It depends upon many factors, as location, the form of the structure, etc.

I will first assume that *one* member always takes up the thrust completely and fully. If the thrust is taken up completely and fully by one member, this member has the form of the line of thrust. If the thrust is scattered over several members, the line

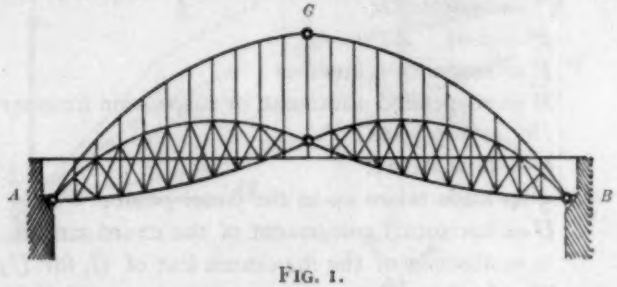


FIG. 1.

of thrust is the locus of the points of application of the thrust in the structure.

The above assumption still leaves it an open question how the moments are taken up. But in looking over the forms and ways already enumerated previously, we see that only *two* distinct divisions exist: a slack and a stiffened bow, and the equations expressing the forces acting in the members of these two kinds of structures will answer also for all combinations.

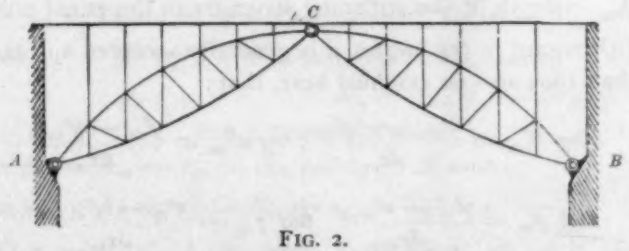


FIG. 2.

Fig. 1 represents a slack bow and a separate stiffening structure. *Fig. 2*, a stiffened bow.

In the slack bow, according to our assumption, the bow strut *A B C* takes up all the thrust and has the form of the line of thrust. In the stiffened bow, I will assume, as it does not matter which chord is selected, that the *upper one* takes up the whole

thrust and has the form of the line of thrust. In both structures a section be made in the mth panel, infinitely near the mth panel point, and the members and the forces acting in it be called as follows:

A = lower chord
T = upper chord
N' = tie
N'' = counter tie
P = post
} of the stiffening truss;

E = suspension member;
B = suspended abutment, or suspension member of the top joint;
D = bow strut;
g = loads taken up in the panel point;
U = horizontal component of the chord strain;
u = abscissa of the maximum line of G_2 for U;
W = horizontal component of the strain in the ties;
w = abscissa of the maximum line of G_2 for W;
p = abscissa of the maximum line of G_2 for P;
Δx = panel length;
$\alpha', \alpha'', \beta, \gamma, \mu$ = angles of the members and strains N', N'', T, A, D with the x axis;
ρ = angle of A or T with the X axis.

These angles always measured as acute angles.

$y^0\ y'\ y''$ = ordinate of $A\ .\ T\ .\ D$.
h_m = depth of the stiffening structure in the panel point m.

With regard to the angles, it is generally accepted and assumed and shall thus also be assumed here, that:

$$tng\ \alpha'_m = \frac{y^1{}_{m-1} - y^0{}_m}{\Delta x_m};\ tng\ \alpha''_m = \frac{y^1{}_m - y^0{}_{m-1}}{\Delta x_m}$$

$$tng\ \beta_m = \frac{y^1{}_m - y^1{}_{m-1}}{\Delta x_m};\ tng\ \gamma_m = \frac{y^0{}_m - y^0{}_{m-1}}{\Delta x_m}$$

$$tng\ \mu_m = \frac{y''_m - y''_{m-1}}{\Delta x_m}$$

This assumption fixes the angles as functions of $y^0\ y'\ y''$ in the panel points, leaving the form of the members between the panel points completely arbitrary. The member can have any form,

such as best adapted to resist the forces brought to bear upon it, provided the above rule is kept in the panel points.

Fig. 3.

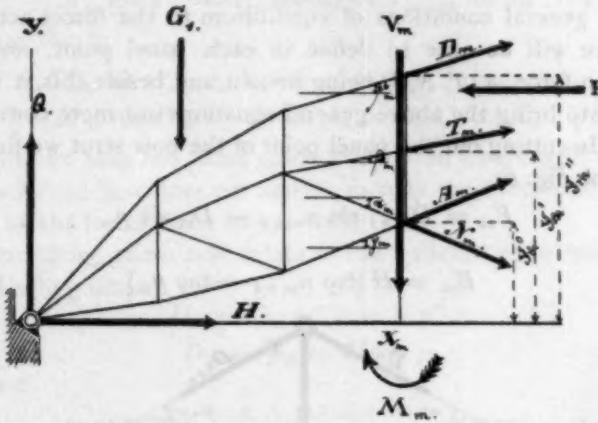


Fig. 3 represents a section in the mth panel infinitely near to mth panel point and the forces acting in it. *Fig. 3* can be used as well for a slack bow as for a stiffened bow, in the latter case D being zero.

From *Fig. 3* we can develop now directly the $\Sigma(x)$ $\Sigma(H)$ $\Sigma(x\,y)$. We have:

FOR A SLACK BOW

$$D_m \cos\mu_m + T_m \cos\beta_m + A_m \cos\gamma_m + N_m \cos a_m - H = o \quad (1)$$

$$D_m \sin\mu_m + T_m \sin\beta_m + A_m \sin\gamma_m - N_m \sin a_m - V_m = o \quad (2)$$

$$(D_m \cos\mu_m - H)\, y_m'' + T_m \cos\beta_m\, y_m' + (A_m \cos\gamma_m + N_m \cos a_m)\, y_m^{\circ} - M_m = o \quad (3)$$

FOR A STIFFENED BOW.

$$T_m \cos\beta_m + A_m \cos\gamma_m + N_m \cos a_m - H = o \quad (1^a)$$

$$T_m \sin\beta_m + A_m \sin\gamma_m - N_m \sin a_m - V_m = o \quad (2^a)$$

$$(T_m \cos\beta_m - H)\, y'_m + (A_m \cos\gamma_m + N_m \cos a_m)\, y^{\circ}_m - M_m = o \quad (3^a)$$

to which must be added according to the premises:

$$D_m = \frac{H}{\cos\mu_m}$$

or

$$D_m \sin\mu_m = H \operatorname{tng}\mu_m$$

These equations give A, T, N, D.

Still, in accordance with the equilibrium of the forces in the whole structure, the forces must also be in equilibrium in each panel point. Hence in cutting out the panel points, and in applying the general conditions of equilibrium to the forces acting in each, we will be able to define in each panel point, *one more* unknown force, A, T, N, D being known, and beside this, it will be possible to bring the above general equations in a more convenient form. In cutting out the panel point of the bow strut we find (see *Fig. 5* or *Fig. 6*)

$$E_m = D_{m+1} \sin \mu_{m+1} - D_m \sin \mu_m$$

or

$$E_m = H(tng\ \mu_{m+1} - tng\ \mu_m) \qquad \text{(VIII)}$$

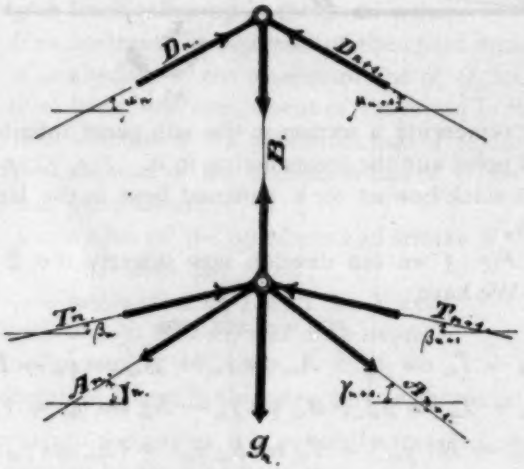


FIG. 4.

In cutting out the top joint of a slack bow, or the hanging abutment, we have:

$$B = D_n \sin \mu_n + D_{n+1} \sin \mu_{n+1}$$

or

$$B = H(tng\ \mu_n + tng\ \mu_{n+1}) \qquad \text{(IX)}$$

or from the bottom:

$$B = (T_n \sin \beta_n + T_{n+1} \sin \beta_{n+1}) - (A_n \sin \gamma_n + A_{n+1} \sin \gamma_{n+1}) + g_n$$

wherein g represents the loads taken up on bottom of B.

In place of A or T, strains of ties may take place, without altering the above results.

In cutting out the mth panel point of the lower and the $(m-1)^{th}$ panel point of the upper chord (see *Fig. 5*) we find:

$$\left.\begin{aligned} N'_m \cos \alpha'_m &= A_{m+1} \cos \gamma_{m+1} - A_m \cos \gamma_m \\ N'_m \cos \alpha'_m &= T_m \cos \beta_m - T_{m-1} \cos \beta_{m-1} \end{aligned}\right\} \quad (V^a)$$

and (see *Fig. 6*)

$$\left.\begin{aligned} N''_m \cos \alpha''_m &= A_m \cos \gamma_m - A_{m-1} \cos \gamma_{m-1} \\ N''_m \cos \alpha''_m &= T_m \cos \beta_m - T_{m+1} \cos \beta_{m+1} \end{aligned}\right\} \quad (V^b)$$

Whether we take the panel point from a structure with slack or with stiffened bow does not matter, as only the horizontal components of the forces come in question.

Introducing these new values in the general equations 1, 2, 3, and minding that:

$$D_m \cos \mu_m \, y''_m = H \, y''_m$$
$$D_m \sin \mu_m = H \operatorname{tng} \mu_m$$

we have

FOR A SLACK BOW:

$$T_m \cos \beta_m + A_{m+1} \cos \gamma_{m+1} = 0 \quad (4)$$

$$T_m \sin \beta_m + A_m \sin \gamma_m - N_m \sin \alpha_m = S_m \quad (5)$$

$$T_m \cos \beta_m \, y'_m + A_{m+1} \cos \gamma_{m+1} \, y^o_m = M_m \quad (6)$$

FOR A STIFFENED BOW

if we write:

$$T_m = \tau_m \pm H$$

as the upper chord is supposed to take up the whole thrust:

$$\tau_m \cos \beta_m + A_{m+1} \cos \gamma_{m+1} = 0 \quad (4^a)$$

$$\tau_m \sin \beta_m + A_m \sin \gamma_m - N_m \sin \alpha_m = S_m \quad (5^a)$$

$$\tau_m \cos \beta_m \, y'_m + A_{m+1} \cos \gamma_{m+1} \, y^o_m = M \quad (6^a)$$

Multiplying eq. (4^a) or (4) alternatively with y^o_m and y''_m, and deducting eq. (6) or (6^a) we find then, if we remember that the moments can be as well positive as negative, and that $y'_m - y^o_m = h_m$ is the depth of the stiffening structure in the point under consideration.

FOR A SLACK BOW.

$$A_{m+1} \cos \gamma_{m+1} = \pm \left(\frac{M}{h}\right)_m$$

$$T_m \cos \beta_m = \pm \left(\frac{M}{h}\right)_m$$

FOR A STIFFENED BOW.

$$A_{m+1} \cos \gamma_{m+1} = \pm \left(\frac{M}{h}\right)_m$$

$$\tau_m \cos \beta_m = (T_m \pm H) \cos \beta_m = \mp \left(\frac{M}{h}\right)_m$$

or,

$$T_m = \mp \left(\frac{M}{h}\right)_m \pm H$$

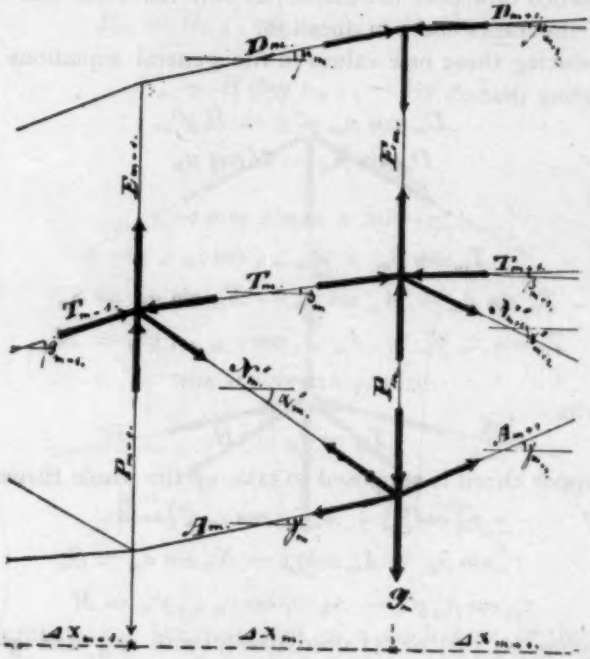


FIG. 5.

From these expressions follows, as the lower chord as well as the upper one, can take up the thrust, the general expression of the *horizontal component of the chord strains:*

$$U_m = \pm \left(\frac{M}{h}\right)_m \pm H$$

In this expression H is zero, if the thrust is *not* taken up by the chord in question. But not only H may become zero, M also

can be zero in certain panels, and then the above equation takes the form:

$$U_m = \pm H$$

It is thus necessary to be very careful in calculating the chord strains, as the moments become generally zero in one panel point of the chord only, creating in this way *one* panel in the chord, in which the chord strains are completely different of the strains in

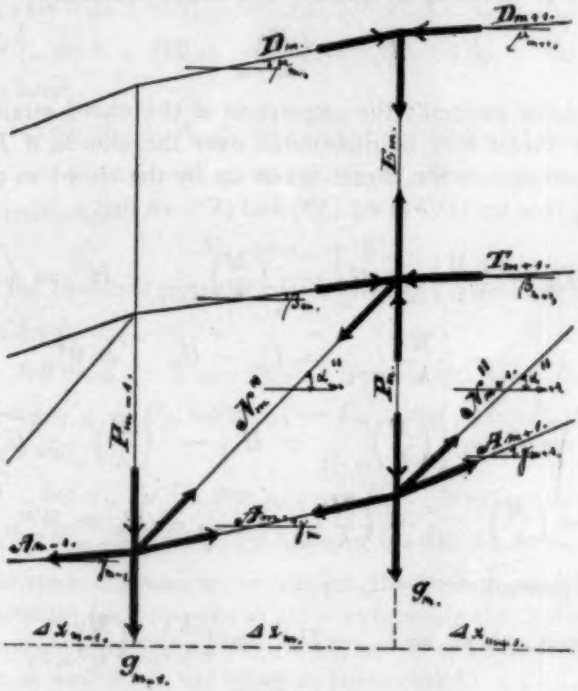


FIG. 6.

all the other panels. The above equation gives the following combinations:

$$U_m = \pm \left[\left(\frac{M}{h} \right)_m + H \right]$$

$$U_m = \pm \left[\left(\frac{M}{h} \right)_m - H \right]$$

Hence we can write quite generally *without* regard to the sign,

$$U_m = \left(\frac{M}{h} \right)_m \pm H \qquad \text{(IV)}$$

We have assumed that the thrust strains were taken up, fully and completely by *one* chord, but the above equation of the chord strains shows that the results of the investigations and the investigations themselves would not change in the slightest way, if the thrust were distributed over both chords. The only difference would be, that in place of the whole thrust a part of it $= K\,H$ would go in the chord strain of one chord, and the balance, or $(1 - K)\,H$ in the other chord. The above equation:

$$U_m = \left(\frac{M}{h}\right)_m \pm H$$

is thus quite generally the expression of the chord strains, however the thrust may be distributed over the chords, if H represents that part of the thrust taken up by the chord in question. In using now eq. (IV) in eq. (V^a) and (V^b) we find:

$$N'_m \cos \alpha'_m = \left[\left(\frac{M}{h}\right)_m \pm H\right] - \left[\left(\frac{M}{h}\right)_{m-1} \pm H\right] = \left(\frac{M}{h}\right)_m -$$

$$- \left(\frac{M}{h}\right)_{m-1} = U_m - U_{m-1} = W'_m$$

$$N''_m \cos \alpha''_m = \left[\left(\frac{M}{h}\right)_{m-1} \pm H\right] - \left[\left(\frac{M}{h}\right)_m \pm H\right] =$$

$$= \left(\frac{M}{h}\right)_{m-1} - \left(\frac{M}{h}\right)_m = U_{m-1} - U_m = W''_m$$

or quite generally

$$W_m = N_m \cos \alpha_m = U_m - U_{m-1} = \left(\frac{M}{h}\right)_m - \left(\frac{M}{h}\right)_{m-1} \qquad (V)$$

This equation is of the greatest importance for the knowledge of the way, in which the forces are acting in the structure.

In substituting eq. (IV) and eq. (V) in eq. (4), (5), (6), or eq. (4^a), (5^a), (6^a), we can for the rest bring N_m also in the form:

$$N_m = \frac{S_m - \left(\frac{M}{h}\right)_m (tng\ \beta_m + tng\ \gamma_m)}{sin\ \alpha_m \pm cos\ \alpha_m\ tng\ \beta_m}$$

In cutting out the panel point of the lower or upper chord and decomposing the forces in the direction of the Y axis, we shall

find the strains in the posts, but there are *three* distinct cases to investigate:

(1) *One* tie is acting.
(2) *Two* ties are acting.
(3) *No* tie is acting.

ONE TIE IS ACTING.

Upper Chord.

$$N'_{m+1} \sin \alpha'_{m+1} + T_{m+1} \sin \beta_{m+1} - T_m \sin \beta_m + E_m = P_m$$

$$N''_m \sin \alpha''_m + T_{m+1} \sin \beta_{m+1} - T_m \sin \beta_m + E_m = P_m$$

Lower Chord.

$$N'_m \sin \alpha'_m + A_{m+1} \sin \gamma_{m+1} - A_m \sin \gamma_m - g_m = P_m$$

$$N''_{m+1} \sin \alpha''_{m+1} + A_{m+1} \sin \gamma_{m+1} - A_m \sin \gamma_m - g_m = P_m$$

or in introducing

$$N_m \cos \alpha_m = W_m$$

and for the chords strains the corresponding U, we have:

Upper Chord.

$$W'_{m+1} tng \alpha'_{m+1} + U_{m+1} tng \beta_{m+1} - U_m tng \beta_m + E_m = P_m$$

$$W''_m tng \alpha''_m + U_m tng \beta_{m+1} - U_{m-1} tng \beta_m + E_m = P_m$$

Lower Chord.

$$W'_m tng \alpha'_m + U_m tng \gamma_{m+1} - U_{m-1} tng \gamma_m - g_m = P_m$$

$$W''_{m+1} tng \alpha''_{m+1} + U_{m+1} tng \gamma_{m+1} - U_m tng \gamma_m - g_m = P_m$$

From these expressions we deduct the general equation of P, in introducing for β or γ the angle ρ expressing the inclination of the chord member against the x axis, and in remembering that E or g can as well act in the upper as lower chord.

$$P_m = W_m tng \alpha_m + U_m tng \rho_m - U_{m-1} tng \rho_{m-1} \pm E_m \mp g_m$$

TWO TIES OR NO TIE ACTING.

Both cases are identical. When two ties are acting on one end of the post the other end must necessarily be free of the action of any tie, as N'_m and N''_m can never act together at once in one and the same panel, being in tension.

Two ties or no ties correspond thus to the case of $W = o$, and we have:

$$P_m = U_m tng \rho_m - U_{m-1} tng \rho_{m-1} \pm E_m \mp g_m$$

These equations give the internal strains of the structure as functions of M and H, and it remains now to show how the maximal and minimal values of the forces in the members of the bow are found. But before I enter into these investigations, I will deduct from the above equations some quite

GENERAL RULES.

We have:

$$U_m = \left(\frac{M}{h}\right)_m \pm H \qquad \text{(IV)}$$

$$W_m = \left(\frac{M}{h}\right)_m - \left(\frac{M}{h}\right)_{m-1} = U_m - U_{m-1} = \Delta U_m \qquad \text{(V)}$$

$$P_m = W_m \operatorname{tng} \alpha_m + U_m \operatorname{tng} \rho_m - U_m \operatorname{tng} \rho_{m-1} \pm E_m \mp g_m \qquad \text{(VI)}$$

$$D_m = \frac{H}{\cos \gamma \, \mu_m} \qquad \text{(VII)}$$

$$E_m = H(\operatorname{tng} \mu_{m+1} - \operatorname{tng} \mu_m) \qquad \text{(VIII)}$$

$$B = H(\operatorname{tng} \mu_{n+1} + \operatorname{tng} \mu_n) \qquad \text{(IX)}$$

and from the first part:

$$M \;.\; S \;.\; H.$$

If we consider these equations, we see that quite generally U, W and P have the same relations to each other as M . S . and W, to wit:

M	U
$S = \frac{M_{m-1} - M_m}{\Delta x_m}$	$W = \Delta U_m = U_m - U_{m-1}$
$W = S + K M$	$P = W + K' U$

if we represent W, which is

$$\left(\frac{M}{h}\right)_m - \left(\frac{M}{h}\right)_{m-1}$$

by $K M$.

In the first serie S is the increment *of M per unit of length*, in the second serie W is the *total increment of U*. W is thus a very important strain, and I shall make use of the above property to decide the maxima and minima of U.

Still another quite general property of the bow structures can be deducted from the above equations with the aid of the first part.

As we know from the first part, those structures whose lines of thrust coincide with one of the sides of the deciding triangle, or structures with a *straight line*, as line of thrust, have their maximum and minimum of the moments with full-loaded or empty girder, and it will be, if the line of thrust coincides with $D\ C$ or the upper side of the deciding triangle $a = o$, if $A\ C$ or the lower side of the deciding triangle is the line of thrust $c = o$, that is all; *all the forces, with exception of H, are then independent of the loadings of one-half of the structure.*

If we consider now the expression of E, we see that in case of a *straight line of thrust, no thrust at all* is transmitted to the members of the structure, μ_m being μ_{m+1}, and $E = o$. *In case of a straight line of thrust, the bow structure is thus reduced to two inclined ordinary beams—struts—whose longitudinal members have to bear an additional thrust.*

(*To be continued.*)

OBITUARY.

Barnabas H. Bartol.

Barnabas H. Bartol, who died in this city upon the 10th of February, 1888, was one of Philadelphia's ablest engineers and one of the warmest friends of the Franklin Institute.

He was born at Freeport, Cumberland County, Me., October 31, 1816, the son of Barnabas Bartol, and Rebecca, his wife, who removed, eighteen months later, to Portland, Me., where he became largely interested in shipping interests. In 1830, he removed with his family to New York.

The subject of this memoir was educated at a private school, taught by a Mr. Jackson.

On the 4th of March, 1833, being then sixteen years four months old, he was entered as an apprentice, until of full age, with Messrs. Kemble, who conducted a branch of the West Point Foundry in New York. It is said that his father wished him to enter the office and drawing room, but it was his own plan to

become a regular apprentice for the purpose of acquiring a thorough knowledge of the practice and details of the profession.

He thus exhibited at the outset a leading characteristic, which was illustrated during all of his subsequent career. In 1835, he was sent as an assistant to erect a coal-winding engine near Richmond, Va., and also in the same year to assist in the erection of water works machinery in the city of New Orleans. In 1837, while still an apprentice, he was sent in charge to erect the first beam engine on Seneca Lake on the steamboat *Richard Stevens*, and in the summer of the same year to the vicinity of Richmond, Va., to erect a winding engine in the coal mines. In both of these last-mentioned works, he was assisted by a fellow-apprentice, W. W. Wood, subsequently of the United States Navy and Chief of Bureau of Steam Engineering.

Becoming of age, October 31, 1837, and free from his apprenticeship, he went to East Boston, with a view of engaging in business, but was prevented by the disastrous effects of the reduction of the import duties under the operation of the "Compromise Act" of 1833, which deranged business generally. He returned to the West Point Foundry, and in October, 1838, was sent to the Island of Cuba to erect sugar machinery.

On his return in June, 1839, he found the New York branch of the West Point Foundry consolidated with the parent establishment at Cold Spring. About the same time, the engineer and Superintendent, Mr. Charles W. Copeland, retired, being engaged by the Navy Department to design the machinery of the steam frigates *Mississippi* and *Missouri*. Messrs. Kemble offered the vacant position to MR. BARTOL, who was then not quite twenty-three years old. He accepted, and remained in their employ until September, 1847, when he resigned and removed to Philadelphia, to become the engineer and Superintendent of the Southwark Foundry, then belonging to Messrs. Merrick & Towne, and subsequently to Messrs. Merrick & Son. In this employ and capacity he remained until January 1, 1867.

During this period many important works were executed by the firm, some of which were designed by him personally; among them may be mentioned, as most important, the machinery of the United States ship *Wabash*, and the hull and armor plating of the United States steam iron-clad *New Ironsides*, besides many other steamers.

His design submitted upon the invitation of the Chesapeake & Delaware Canal Company, for competitive plans for supplying their locks with water was awarded the premium and the work was executed from his drawings, and under his supervision.

The work of the Southwark Foundry during his incumbency as Superintendent was large, varied and important. The knowledge of machinery for gas making possessed by the founder, Mr. S. V. Merrick, brought it many orders and contracts for building and extending works in the country. The contracts by which the firm became the exclusive agents of Mr. James Nasmyth, the inventor of the steam hammer, and of M. Norbert Rillieux, inventor of the famous "triple effect" system of boiling cane juice into sugar, brought to the establishment a large business from both directions, and to MR. BARTOL a large fund of varied experience, which was of great advantage to him afterwards.

We have traced in detail the principal events in MR. BARTOL'S career, whilst he was in a subordinate capacity, because of the striking lesson it presents of the success which attends the strict attention to duties and studies.

The spectacle of a young man under twenty-three years of age, placed at the head of an establishment like the West Point Foundry, where he had lately been an apprentice, is a very remarkable one, and a proof of his acknowledged ability. His successful management, against the jealousies which his promotion would naturally excite, is the best proof of the moral qualities which he afterwards exhibited.

On leaving the Southwark Foundry, MR. BARTOL visited Europe for six months with a part of his family, and inspected the French Exposition of 1867. On his return, he devoted himself to the management of the Grocers' Sugar House, an establishment built by him in 1859, being the first sugar house in Philadelphia to use centrifugal draining machines, and also to the management of the Washington (D. C.) Gas Light Company, of which he was elected President in 1864, and continued in that office until 1883, to the great advantage of the company. In 1872, he was elected a Director of the American Steamship Company, and served eight years as Chairman of the Building Committee.

During the war the President offered to MR. BARTOL the posi-

tion of Engineer in Chief of the United States Navy, but, after consultation, it was decided that he would be of more use to the Government by remaining in Philadelphia and completing the *New Ironsides*, and other vessels upon which he was engaged.

MR. BARTOL'S connection with the FRANKLIN INSTITUTE began soon after his arrival in this city. He served on the Board of Managers for three years, 1863, 1864, 1865. In 1880 he presented to the INSTITUTE $1,000 invested in City 6's. With his consent the interest was devoted to providing prizes of free scholarship to be given to those pupils of the Drawing School who were most deserving. He always exhibited the greatest interest in the prosperity of the INSTITUTE, and was always ready to assist in promoting its welfare.

In 1851, MR. BARTOL published a treatise on "Marine Boilers," which was fully abreast the practice of the day, and contains full details of the boilers of the principal vessels afloat.

MR. BARTOL was married in 1842 to Miss Emma J. Welchman, originally of England, by whom he had four children, two sons and two daughters, who all survive him.

One who knew him intimately, writes:

"The perfect harmony which always existed between MR. BARTOL and myself enabled us to work together without the slightest friction, and no disagreement ever arose between us during our long association of twenty years.

"MR. BARTOL'S characteristics were: (1) Method and attention to details in managing the work both in its execution, its shipment and its erection. (2) Uncompromising discipline and control over subordinates, yet combined with a sufficiently affable manner; every one had confidence that while he would be kept up to the line of duty, he would be treated considerately. (3) A direct practical judgment—no room given for sentiment or imagination—the question at issue being decided on its merits and generally with accuracy.

"This judgment derived much of its value from his thorough mastery of details acquired during his early training. He saw what would be required, how it could be done and how soon, and decided accordingly."

Mr. BARTOL possessed superior administrative abilities, coupled with untiring energy and perseverance, and a comprehensive

knowledge of his profession. These qualities, with eveness of temper and straightforward honesty, formed a combination rarely found, and fitted their possessor for the responsible positions filled by him, and brought success to the enterprises of a busy, well-spent life.

W. P. TATHAM, WM. SELLERS, WASHINGTON JONES.

BOOK NOTICES.

MANAGEMENT OF ACCUMULATORS AND PRIVATE ELECTRIC LIGHT INSTALLATIONS. A practical hand-book by Sir David Salomons. pp. 150. Third edition. London: Whittaker & Co. 1888.

When storage batteries first came into use it was claimed by many that they would revolutionize electric lighting; but it was soon found, after they had been in use for a short time, that numerous unforeseen and serious difficulties presented themselves, and that, therefore, the only way to find out their true value was to conduct long series of experiments with them in actual practical installation. This little volume, will, therefore, be very acceptable to those interested in the subject, as giving the experience of one who has for a number of years used accumulators for a private installation, and who is, therefore, competent to give an unbiased description of their behavior, their "idiosyncrasies" and the results of their continued use.

The matter contained in the book is, to a great extent, comprised of the results of the author's personal experience with accumulators of a particular type, in the private lighting installation at his residence. The book is chiefly for amateurs and persons who are not electricians, but it may also be read with profit by electricians who have not had much personal experience with the management and behavior of accumulators. With a few exceptions, the language is clear and concise and requires but little familiarity with the subject on the part of the reader. In a few cases, statements are made as facts, while they are really matters of opinion only, which may be misleading to the inexperienced. In a few other cases, his too positive assertions might better have been modified somewhat, while others will bear correction.

The author limits himself almost entirely to a particular company's cells, but his statements apply, in a great measure, also to accumulators in general which resemble this type, namely, those having plates consisting of lead grids having their meshes filled with the active material. In endeavoring to assist parties in selecting reliable apparatus, the author has given some parts of the book the appearance of advertisements of certain firms. A few statements are not quite correct; "force" and "energy," for instance, are not synonymous terms, and a "watt" is a measure of *power*, and not of "force." About half of the book is devoted to accumulators, and the other half to the remaining parts of an installation, the former being by far the more important part of the book.

In the first few chapters, the author describes the particular cells, namely, the E. P. S. cell, and gives much valuable information regarding the details which should be observed in setting up, charging and discharging the cells, giving the causes of failure and their remedies. Among other information which may not be generally known, he states that "sunlight falling upon the cells is a constant source of breakage." He gives as the proper rate of charging and discharging, 5·3 ampères and 6·1 ampères per square foot of positive plate respectively, and dwells on the great importance of not exceeding these figures.

From a few remarks he makes, we cannot but conclude that even in this model installation there is much room for improvement. For instance, he states that gas is given off at all periods of the charge (which, of course, represents loss of energy); that unless well ventilated it is almost impossible to enter the apartment during charging hours, on account of the gases; and that a charging current of one-tenth the normal does not appear to charge the cells (presumably on account of the leakage). For total efficiency on the long run, he states that more than sixty-five to seventy per cent. cannot be counted upon. A few tables which are given contain some useful figures regarding the storing capacity and weights of various cells. The chief faults of storage batteries of this type are the buckling of the peroxide plates and the falling out of the active material from the meshes in the grids. Unfortunately, nothing is said of the length of time the peroxide plates will last before their grids are peroxidized throughout, which determines their life, and which is a very important factor in determining the cost of running a plant, as these plates, he admits, are quite expensive.

The accessory apparatus of an installation the author describes in detail, calling attention to important points, and recommending apparatus of certain firms as a guide to installers of plants. He states that "Edison's meter is a thing of the past; * * * * it requires a shunt resistance and, therefore, is wasteful for large currents." We would remark here that all meters having, like Edison's, an approximately constant total resistance, are alike in consuming a larger amount of energy as the current increases.

He describes at some length one of the most important pieces of apparatus in such a plant, namely an automatic switch for preventing the accumulators from discharging through the dynamo. But unfortunately the diagram of this (page 115) is incomplete and not clear, and therefore almost worthless to one not able to supply what is omitted.

The latter part of the book contains a table of estimates of the various items and totals in the first cost and cost of running small private plants from twenty-five to 120 lamps, with and without accumulators. The figures and the deductions from them are of considerable interest and may be of great use to anyone making such estimates or comparisons.

The concluding chapter gives a brief account and history of the author's private installation at Broomhill, in which he gives the expense accounts and deduces the cost per sixteen candle-power lamp per hour, which he states was, in 1887, at the rate of three-eighths pence, or about three-fourths of a cent, even under very unfavorable circumstances.

Apart from the few points to which exception may be taken, the book may be highly recommended to persons interested in the subject, and who have not had a similar practical experience with accumulators, some parts being of interest and use even to the experienced electrician. It is an important and valuable addition to the scant amount of literature on this important subject. It is hoped that the author will supplement it in the near future with additional information, particuiarly with reference to the life of the cells. C. H.

THE ANOINTED SERAPH. "The last made first." By G. H. Pollock. Vol. I. John F. Sherry, printer and publisher, 623 D Street, N. W., Washington. 1888.

This little book is a fine sample of the sort of structure a morbid mind can raise when it has for material a supposed divine revelation. It is an utterly unintelligible jumble of meaningless mysticisms about nothing at all, as the following extract will illustrate:

"The earth which we inhabit, and of which we are a part, was made up, through involution, of all the various products and qualities of the disturbed stellar lights: Water came from Taurus, oxygen from the Great Bear, amativeness from Capricornus, copper from the Whale, steel from the Little Bear, gems from Scorpio, black hair from Aquarius, gold from the Crown, salt from Orion, mercury from Mercury, sulphur from Jupiter, alkaline substance from Venus, diamonds from Andromeda, verdigris from the Sun-spots, iron from Hercules, silver from the Pleiades, soapstone from Hydra, loadstone from the Pole Star. The life of the world was the nature and personality of the Digressor from the seventh sun, who, through the process of involution, became inverted; passing from the Divine to the natural state." T.

PHOTOGRAPHY APPLIED TO SURVEYING. By Lieut. Henry A. Reed, U. S. A. New York: Jno. Wiley & Sons.

Among the most recent contributions to engineering literature is Lieut. Henry A. Reed's interesting work on "Photography Applied to Surveying." As the author states, the principles involved in the use of photographs for map construction are old, though, in this country, at least, their practical application is very rare.

The general principles, as set down by Lieut. Reed, are exactly the same as for ordinary surveying. A point is determined from the station, horizontally, by the intersection of two "spots" or "views" from given points, or by its azimuth and distance, and, vertically, by measuring the angle of elevation or depression.

The field work with the camera consists simply in taking views, with compass bearings, from stations either previously determined or not, so as to include as much of the tract to be surveyed as possible.

These data suffice for making an exceedingly complete and surprisingly accurate topographical map. The author states that, with care, the maximum error in determining a point 2,700 yards off would not be over twenty inches

in distance or thirty seconds in angular height. Reduced to a scale of 1:5000 (one of the scales used by the Corps des Ponts et Chaussées for exact details), such inaccuracies would be inappreciable.

The latter part of Lieut. Reed's book is taken up in describing improved French photographic instruments for surveying, as well as telescopic and balloon photography, showing that this method of photographic surveying has acquired a foothold abroad.

When the great saving of time in both field work and plot are considered, it becomes important for engineers to investigate a method that for ordinary purposes gives such remarkably good results. For this purpose, Lieut. Reed's work is admirably adapted. C. H. H.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, May 16, 1888.*]

HALL OF THE INSTITUTE, May 16, 1888.

Mr. JOS. M. WILSON, President, in the Chair.

Present, 348 members and fifty-one visitors.

Additions to membership since last report, fifteen.

Mr. EMILE BERLINER, of Washington, read a paper on his lately-invented apparatus for recording and reproducing musical sounds and speech, called the "Gramophone." Mr. BERLINER'S paper contained a historical sketch of the progress of invention in this field and a detailed description of his own method and apparatus. The speaker illustrated his paper with the aid of the lantern, and by the exhibition of the apparatus. He demonstrated its capabilities by recording on one of his prepared zinc plates several songs and speeches, etching the plate, and reproducing the songs and words then and there. Several etched record plates, prepared previous to the meeting, were likewise presented, and the reproducing apparatus faithfully emitted the songs and spoken words recorded upon them. The reproduction was loud enough to be distinctly audible all over the lecture room. The music could be easily recognized; speech, though not so clearly rendered, was, for the most part, intelligible.

Mr. BERLINER explained that the apparatus which he exhibited was the first that he had constructed, and that it had only been finished a few days before. He felt satisfied that after some experience with it he would be able to make such betterments in its mechanical details as would substantially improve its performance.

On Prof. HOUSTON'S motion, a unanimous vote of thanks was tendered to Mr. BERLINER for his most interesting paper and demonstration.

The Secretary called attention to a remarkable suite of specimens of various forms of iron and steel that had been produced by rolling with the Simonds rolling machine, and added that a paper on the subject would be read at the stated meeting in June.

Adjourned. WM. H. WAHL, *Secretary.*

PENNSYLVANIA STATE WEATHER SERVICE.

NOVEMBER, 1887.

SUMMARY OF METEOROLOGICAL REPORTS

MADE BY VOLUNTARY OBSERVERS,

——TO THE——

METEOROLOGICAL COMMITTEE OF THE

FRANKLIN INSTITUTE,

PHILADELPHIA, PA.

T. F. TOWNSEND, Sgt. Signal Corps, Assistant.

PENNSYLVANIA STATE WEATHER SERVICE BULLETIN FOR NOVEMBER, 1887.

HALL OF THE FRANKLIN INSTITUTE.

PHILADELPHIA, December 1, 1887.

Owing to delays in procuring a supply of standard instruments, the number of stations reporting and represented in the annexed summary is the same as last month, but it is gratifying to notice the improvement of the service, as shown by the increase of the data contained in the reports, as well as by evident marks of more careful preparation.

The committee is assured that the instruments are about ready, and they will be sent out as soon as practicable to the observers who have been waiting for them.

Attention is again called to the value of local newspaper clippings containing matter of information to the service, and observers are requested to forward them with their reports.

The committee would be glad to hear from Senators or Representatives from counties where stations are not yet established, so as to be assisted in making proper selections of observers, and to confer with parties properly recommended, who desire to take part in the work.

It is very desirable to have records from each county, beginning with the new year.

For the Committee, etc. W. P. TATHAM, *Chairman.*

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather S

County.	Station.	Barometer.			Temperature.												Relative Humidity.	Dew Point.	Precipitation		
						Maximum.		Minimum.				Daily Range.									
		Mean.	Highest.	Lowest.	Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Greatest.	Date.	Least.	Date.			Total Inches.	Greatest in 24 Hours.	Date.
Allegheny,	Pittsburgh,	30·061	30·834	29·341	44·7	74·2	27	14·2	29	52·3	35·8	32·2	27	4·1	25	68·1	33·8	1·37	·52	24
Bedford,	Charlesville,	. . .	. . .	. . .	36·1	70·	27	12·	29	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	·90	·19	10
Blair,	Hollidaysburg,	. . .	. . .	. . .	39·0	73·	27	13·	29	51·	27·	44·	2, 7	4·	20	68 4	29·7	1·13	·43	25
Bradford,	Wysox,	. . .	. . .	. . .	38·4	68·	27	10·	30	38·	29·9	40·5	28	6·	21	. . .	. . .	2·38	·85	24
Bucks,	Quakertown,	30·088	30·819	29·444	38·7	67·	27	18·	29, 30	50·	25·9	34·	2	4·7	24	75·	30·3	1·56	·59	19
Bucks,	Fallsington,*	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Cameron,	Emporium,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Centre,	Phillipsburg,	. . .	. . .	. . .	32·7	64·	6	10·	30	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1·36	·23	11
Centre,	State College,	30·121	30·942	29·521	38·4	70·	27	8·5	30	46·6	27·6	43·	28	5·5	15	78·6	32·2	1·44	·46	28
Chester,	West Chester,	30·084	30·825	29·453	41·1	65·5	26, 27	20·	30	49 5	33·6	32·	28	3·5	15	68·	31·2	2·1 .	·61	19
Clarion,	Clarion,	. . .	. . .	. . .	38·7	68·	27	8·	29	46 6	30·1	38·	2	5·	11, 12	76·3	28·5	2 45	1·05	25
Clearfield,	Grampian Hills,	30·050	30·768	29·443	35·6	70·	27	12·	29	43 2	27·4	30·	2	2·	11, 12	. . .	. . .	2·28	80	25
Columbia,	Catawissa,	. . .	. . .	. . .	. . .	71·	27	15·5	30	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1·66	. . .	. . .
Crawford,	Meadville,	30·096	30·839	29·347	42·7	67·	27	18·	30	. . .	. . .	. . .	. . .	. . .	. . .	61·7	29·6	. . .	. . .	. . .
Cumberland,	Carlisle,	. . .	. . .	. . .	40·3	70·	27	21·	22	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	·96	·40	28
Delaware,	Swarthmore,	30·072	30 813	29·458	41·4	67·4	27	21·1	30	50·3	33·7	30·3	2	5·8	25	78·6	35·4	1·57	·51	1
Elk,	Ridgway,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Erie,	Erie,	30·039	30·920	29·330	39·8	69 9	27	14·4	30	51·4	32·2	. . .	. . .	. . .	. . .	76·6	32·7	4·13	. . .	. . .
Fayette,	Uniontown,	30·038	30·670	29·430	44·0	75·	27	14·	29	52·8	34·5	37·	3	5·	15	82·2	41·	1·01	·43	11
Franklin,	Chambersburg,	. . .	. . .	. . .	36·2	66·5	27	18·	22, 29	50·8	29·	38 5	7	6·	11	79·3	29·9	1·04	·40	10
Fulton,	McConnellsburg,	. . .	. . .	. . .	39·1	72·	27	15·	29	52·	28·4	46·	2	6·	24	76·3	32·2	1·21	·48	28
Huntingdon,	Huntingdon,	. . .	. . .	. . .	37·9	72·2	27	14·	30	50·6	26·2	43·3	3	8·	15	73·9	30·	1·61	·45	28
Indiana,	Indiana,	. . .	. . .	. . .	36·7	74·	27	9·	29	48·4	29·5	40·	2	2·	20	79·7	35·7	2·44	·69	25
Lackawanna,	Scranton,	. . .	. . .	. . .	37·7	71·	27	12·	30	49·7	28·4	42·	28	8·	24	81·5	32·4	1·95	·53	28
Lancaster,	Lancaster,	30·112	30·840	29·495	40·5	70·4	27	19·8	29	50·3	31·7	33·3	28	5·7	15	73·2	31·4	. . .	. . .	. . .
Luzerne,	Drifton,	. . .	. . .	. . .	36·5	68·	28	6·	30	39·3	28·6	47·	28	9·	11	. . .	. . .	2·10	·60	28
Lycoming,	Williamsport,	. . .	. . .	. . .	37·4	68	27	17·	22	. . .	29·6	. . .	. . .	. . .	. . .	78·9	31·7	1·69	·71	28
Mercer,	Greenville,	. . .	30 842	29·440	37·2	67·9	27	8·4	29	47·2	28·7	41·	2	4·8	12	73·9	28·8	2·38	·44	11
Montgomery,	Pottstown,	. . .	. . .	. . .	40·5	68·	4	21·	30	50·9	33·3	32·	6	4·	15, 25	69·3	34·8	1·48	·7	19
Northampton,	Bethlehem,	30·036	30·707	29·510	40·5	68·	27	19·	30	49·5	30·3	37·	2, 4	6·	15. 24	78·2	35·4	1·32	·69	19
Philadelphia,	Philadelphia,	30·073	30·820	29·460	45 3	69·6	27	25·	31	53·2	38·6	28·4	28	5·2	15	62·4	31·	1·38	·48	10
Pike,	Blooming Grove,	. . .	. . .	. . .	36 7	66·	27	14·	30	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1·80	·60	25
Schuylkill,	Girardville,	. . .	. . .	. . .	40·0	65·	4, 27, 28	28·	30	50·4	31·	35·	3	2·	24	. . .	. . .	1·98	·69	28
Somerset,	Somerset,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Tioga,	Wellsboro,	. . .	. . .	. . .	37·2	71·	27	1·	30	47·2	29·9	62·1	27	11·2	30	71·2	28·	2·09	1·60	28
Washington,	Washington,	. . .	. . .	. . .	41·5	79·5	27	13·	29	45·8	33·1	35·	2	2·	19	. . .	. . .	2·38	·87	20
Wayne,	Dyberry,	. . .	. . .	. . .	34·9	65·	27	7·5	21	44·2	24·2	37·	28	4·	24	. . .	. . .	2·60	·80	28
Westmoreland,	Greensburg,	. . .	. . .	. . .	41·	74·	27	8 5	30	50·3	29·8	47·8	2	8·	15	77·6	33·	2·45	·47	25

* Mr. Milnor Gillingham died of heart disease, November 12th.

Voluntary Observers of the Pennsylvania State Weather Service for Novem

Temperature.									Precipitation.				Wind.	
			Daily Range.				Relative Humidity.	Dew Point.						
Date.	Mean of Maximum.	Mean of Minimum.	Greatest.	Date.	Least.	Date.			Total Inches.	Greatest in 24 Hours.	Date.	Number of Days Rainfall.	Prevailing Direction.	Cloudy.
9	52·3	35·8	32·2	27	4·1	25	68·1	33·8	1·37	·52	24	7	NW	1
9	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	·90	·19	10	6	W	
9	51·	27·	44·	2, 7	4·	20	68·4	29·7	1·13	·43	25	3	W	
0	38·	29·9	40·5	28	6·	21	. . .	. . .	2·38	·85	24	7	NW	
30	50·	25·9	34·	2	4·7	24	75·	30·3	1·56	·59	19	5	W, NW	1
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	.
0	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1·36	·83	11	7	SW	
9	46·6	27·6	43·	28	5·5	15	78·6	32·2	1·44	·46	28	8	W	
0	49·5	33·6	32·	28	3·3	15	68·	31·2	2·1	·61	19	9	NW	
9	46·6	30·1	39·	2	5·	11, 12	76·3	28·5	2·45	1·05	25	8	SW	1
9	43·2	27·4	30·	2	2·	11, 12	. . .	. . .	2·28	·80	25	7	W	
0	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1·66	. . .	. . .	. . .	. . .	
0	. . .	. . .	. . .	. . .	. . .	. . .	61·7	29·6	. . .	. . .	. . .	. . .	S	1
2	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	·96	·40	28	5	W	1
0	50·3	33·7	30·3	2	3·8	15	78·6	35·4	1·37	·31	1	7	W	
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	.
0	51·4	32·2	. . .	. . .	. . .	. . .	76·6	38·7	4·13	. . .	. . .	14	SW	1
9	52·8	34·5	37·	3	5·	15	82·2	41·	1·01	·43	11	6	NW, SW	
29	50·8	29·	38·5	7	6·	11	79·3	29·9	1·04	·40	10	5	W, NW	
9	52·	28·4	46·	2	6·	24	76·3	32·2	1·21	·48	28	9	W	
0	50·6	26·2	43·3	3	8·	15	73·9	30·	1·63	·45	28	7	W	
9	48·4	29·5	40·	2	2·	20	79·7	38·7	2·44	·69	25	10	SW	1
0	49·7	28·4	42·	28	8·	24	81·5	32·4	1·93	·53	28	10	S	
9	50·5	31·7	33·3	28	5·7	15	73·2	31·4	. . .	. . .	. . .	. . .	W	
0	39·3	28·6	47·	28	9·	11	. . .	. . .	2·10	·60	28	7	NW	1
2	. . .	29·6	. . .	. . .	. . .	. . .	78·9	31·7	1·69	·71	28	7	W	1
9	47·2	28·7	41·	2	4·8	12	73·9	28·8	2·38	·44	11	11	NW, SW	1
0	50·9	33·3	32·	6	4·	15, 25	69·3	34·8	1·48	·7	19	5	W, NW	
0	49·5	30·3	37·	2, 4	6·	15, 24	78·2	35·4	1·32	·69	19	8	W	
1	53·2	38·8	28·4	28	5·2	15	62·4	32·	1·38	·48	10	7	W	
0	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1·80	·60	25	4	W	
0	50·4	31·	35·	3	2·	24	. . .	. . .	1·98	·69	28	6	. . .	
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	.
0	47·2	29·9	62·1	27	11·2	30	71·2	28·	2·09	1·60	28	8	S	1
9	43·8	32·1	35·	2	2·	19	. . .	. . .	2·38	·87	20	7	NW	1
1	44·2	24·2	37·	28	4·	24	. . .	. . .	2·60	·80	28	8	NW	1
0	50·3	29·8	47·8	2	8·	15	77·6	33·	2·45	·47	23	8	W	1

FOR NOVEMBER, 1887.

Wind.	Number of Days.				
Prevailing Direction.	Cloudy.	Frost Occurred.	Snow Occurred.	Lunar Halos.	Observers.
NW	15	8	. . .	. . .	Oscar D Stewart, Sgt. Sig. Corps.
W	9	10	. . .	. . .	Rev. A. Thos. G. Apple.
W	5	. . .	. . .	. . .	Prof. J. A. Stewart.
NW	6	. . .	. . .	. . .	Charles Beecher.
W, NW	15	23	2	. . .	J. L. Heacock.
. . .	. . .	. . .	. . .	. . .	Milnor Gillingham.
SW	7	. . .	4	. . .	. . . . .
W	9	1	3	26, 27	L. Ray Morgan.
NW	5	. . .	1	. . .	Prof. Wm. Frear.
SW	11	4	3	. . .	Jessie C. Green, D.D.S.
W	9	3	3	. . .	J. H. Apple, A.B.
. . .	. . .	. . .	. . .	. . .	Nathan Moore.
S	13	. . .	. . .	. . .	Wm. G. Yetter.
W	15	. . .	2	21	Prof. J. H. Montgomery.
W	5	3	. . .	. . .	J. E. Pague.
. . .	. . .	. . .	. . .	. . .	Prof. Susan J. Cunningham.
SW	10	2	. . .	. . .	Joe Messinger.
NW, SW	9	15	. . .	. . .	Peter Wood, Sgt. Sig. Corps.
. . .	8	6	. . .	22, 27	Wm. Hunt.
W, NW	8	. . .	. . .	26,27,30	Prof. Mary A. Ricker.
W	7	5	. . .	26, 27	Thomas F. Sloan.
SW	12	5	3	25	Prof. W. J. Swigart.
S	7	5	3	. . .	Prof. Albert E Maltby.
W	6	13	3	22, 30	T. F. Heebner, M.D.
NW	11	. . .	. . .	. . .	Prof. Jefferson E. Kershner.
W	10	11	3	28	H. D. Miller, M.D.
NW, SW	11	6	6	. . .	E. H. Baker.
W, NW	7	. . .	2	. . .	Prof. S. H. Miller.
W	7	8	. . .	. . .	Charles Moore, D.D.S.
W	8	10	1	. . .	Lerch & Rice.
W	. . .	. . .	. . .	. . .	Luther M. Dey, Sgt. Sig. Corps.
. . .	. . .	. . .	. . .	. . .	John Grathwohl.
. . .	. . .	. . .	. . .	. . .	E. C Wagner.
S	14	18	. . .	. . .	. . . . .
NW	16	11	. . .	. . .	H. D. Deming.
NW	13	27	4	22, 26	Harrison Otis.
W	12	5	. . .	1, 2	Theodore Day.
					H. S. Brunot.

T. F. TOWNSEND,
Sergeant Signal Corps, Assistant.

REMARKS.

The mean temperature of the State for November was 39°·2, which is about normal.

The highest temperatures occurred on the 27th, and ranged from 65° at Girardville and Dyberry to 79° at Washington.

This extreme was followed by a cold wave on the 29th and 30th, during which the following low temperatures were noted: Wellsboro, 1°; Drifton, 6°; Clarion, 8°; State College, 8°·5; Greenville, 8°·4; Indiana, 9° and Philadelphia, 25°. This cold wave was general throughout the United States, and low temperatures extended to the southern parts.

One of its notable features was its slow progressive easterly movement after reaching the Alleghenys.

The greatest daily ranges of temperature during the month occurred about the 2d, and the least daily ranges on the 11th, 15th and 24th. Until the last of the month, the ground was not frozen, so as to seriously interfere with ploughing. Frosts were numerous and general.

The average rainfall for the State was 1·80 inches, which is but little more than half of the usual quantity for November.

The stations reporting the most are Erie 4·13 inches, Dyberry 2·60 inches, Clarion 2·45 inches, Indiana 2·44 inches, Wysox and Greenville each 2·38 inches. The least occurred at Charlesville, ·90 inch and Carlisle ·96 inch. The dates on which general rains occurred were the 10th, 11th, 14th, 15th, 19th, 20th, 24th, 25th and 28th.

Much inconvenience has been experienced in many counties from the drouth. In Clearfield and Luzerne Counties streams and wells are reported very low. In Northumberland, the scarcity of water has been severely felt at the collieries. During the entire month the fear of a water famine was general in Berks County. Farmers were hauling water in barrels for home use and cattle were driven daily to running streams, often long distances from home. Springs that were never known to fail ceased to flow.

It is said that the Schuylkill has not been so low for many years. Much damage has been done throughout several counties by forest fires. Light snows prevailed throughout the State on the 10th, 11th, 19th, 20th and 30th. The greatest depth reported was six inches at Scranton and Grampian Hills.

Like September and October, the month was free from severe storms. An area of low pressure, reaching 29·330 at Erie, 29·341 at Pittsburgh and 29·460 at Philadelphia, passed over the State on the 19th, attended by light snow and rain, and was followed by a slight cold wave. An unusual high pressure occurred on the 30th, the barometer reaching 30·920 at Erie and 30·820 at Philadelphia. This was attended by the low temperatures of the 29th and 30th. The following mean barometers were reported: Erie, 30·039; Pittsburgh, 30·061; Philadelphia, 30·073. Lunar halos were observed at several stations on the 21st, 22d, 25th, 26th, 27th and 30th. Thunder storms occurred at Grampian Hills on the 11th and at State College on the 28th. Williamsport reports an aurora on the 28th.

T. F. T.

PRECIPITATION FOR NOVEMBER, 1887.

	Pittsburgh.	Charlesville.	Wyaox.	Quaketown.	Phillipsburg.	State College.	Westchester.	Clarion.	Catawissa.	Carlisle.	Swarthmore.	Erie.	Uniontown.	McConnellsburg.	Huntingdon.	Indiana.	Scranton.	Dilton.	Williamsport.	Greenville.	Pottstown.	Bethlehem.	Philadelphia.	Blooming Grove.	Girardville.	Wellsboro.	Washington.	Dyberry.	Greensburg.	Chambersburg.	Hollidaysburg.	Grampian Hills.
	1 37	90	38	1 36	1 44	2 13	2 45	1 66	1 96	1 57	4 13	1 01	1 21	1 63	2 44	1 95	2 10	1 69	2 38	1 48	1 32	1 38	1 80	1 93	2 09	2 38	2 60	2 45	1 04	1 13	2 28
1							.48				.51																					
2																							.96									
3																																
4																																
5																																
6																																
7																																
8																																
9																																
10	.22	.19	.07	.47	.27	.52	.50	.30		.30	.41		.43	.33	.34	.54	.28	.30	.96	.41	.53	.43	.48	.40			.35	.22	.37	.40	.38	.55
11			.05		.04	.03	.15				.01		.03	.02	.05	.08	.21	.05		.43							.05	.10	.07			.15
12																																
13	.24		.02	.19	.10			.03		.07	.08			.07	.30	.30	.08		.22	.27	.12	.09	.01				.13	.08	.37	.08		.32
14	.08	.13			.14		.15	.59		.07				.05	.14	.39	.08		.21	.18			.10						.60			.50
15																.03																
16																																
17																																
18																																
19		.04	.44	.59	.03	.18	.02	.02	.13					.05	.15	.05	.40	.44		.03	.57	.69	.81	.60	.22		.80	.40	.60	.08	.08	
20	.09	.07	.11	.07	.03	.23	.01	.05	.06		.06			.06	.30	.08	.01	.08		.03	.06		.07		.13		.10	.26			.80	
21			.85		.07		.02	.10									.07	.43	.26	.15		.01		.50			.87				.16	
22			.16		.03		.01										.03	.03	.03	.07												
23																																
24	.33	.07			.07	.18	.02	.01					.06	.09	.15	.33	.07		.26	.03							.40	.03			.10	
25	.30	.11	.79			.33	.01	.05		.06			.88	.09	.30	.69	.33	.42	.20	.15		.01		.60	.35		.26	.77	.47		.80	
26	.01							.10									.01		.03	.07												
27	.01	.34		.34																.23												
28																	.53	.60	.71	.32	.20	.10	.35	.30	.69		.17	.43				
29																																
30																																
31																																
	1 37	90	38	1 36	1 44	2 13	2 45	1 66	1 96	1 57	4 13	1 01	1 21	1 63	2 44	1 95	2 10	1 69	2 38	1 48	1 32	1 38	1 80	1 93	2 09	2 38	2 60	2 45	1 04	1 13	2 28

T. F. T.

PENNSYLVANIA STATE WEATHER SERVICE.

DECEMBER, 1887.

SUMMARY OF METEOROLOGICAL REPORTS

MADE BY VOLUNTARY OBSERVERS,

——TO THE——

METEOROLOGICAL COMMITTEE OF THE

FRANKLIN INSTITUTE,

PHILADELPHIA, PA.

T. F. TOWNSEND, Sgt. Signal Corps, Assistant.

PENNSYLVANIA STATE WEATHER SERVICE BULLETIN FOR DECEMBER, 1887.

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, December 31, 1887.

The Committee regrets that it is not yet able to announce the establishment of stations in every county of the State. Several counties are still unprovided for, and those interested in having their sections represented are requested to assist in selecting observers who will take an active interest in the work. Weather signals should be displayed all over the State, and we are now ready to telegraph the indications and cold wave warnings to those who will make the display. A few sets of flags will be furnished by the State Service. Observers are particularly requested to record the amount of precipitation, whether rain or snow, on the day it occurs. Each day should have its own distinct record, no matter how long a rain or snow storm continues. The early mailing of reports at the end of the month will greatly facilitate the early issue of the Monthly Review from this office.

The Committee on Meteorology of the FRANKLIN INSTITUTE,
W. P. TATHAM, *Chairman.*

REMARKS.

The characteristics of the weather of December are similar to those of November in the general moderation of the changes of temperature and the absence of extremes. While the mean temperature of 31°·5 is very nearly that of the absolute mean, the general climate has been mild rather than severe.

The equable temperatures, and the absence of heavy snow falls during the first and middle parts of the month, have been favorable for the continuance of building operations, plowing, and the usual out-door work performed at this season of the year.

The month has been favorable to the growth of winter wheat, which is reported in excellent condition. The pasturage of the lower counties has been of value.

The coldest period of the month was from the 22d to the 31st, inclusive, the cold of the first being of short duration. The lowest temperatures reported are from Dyberry, —6° on the 31st; Lancaster, —3°·8, 29th; Wysox, 0°·5, 31st; Phillipsburg, 0°·0, 1st; Scranton, 3°·5, 1st; Pittsburgh, 7°·5, 29th; Philadelphia, 14°·5, 29th. The highest temperatures occurred on the 4th, 10th and 11th, and ranged from 50° to 60°.

Most of the high barometric pressures were on the 1st, and the lowest on the 17th and 18th. The latter was attended by general rains and snows, which were heavy east of the Alleghenies.

With the exception of the 1st, 6th and 13th, rain or snow fell in measurable quantities on every day of the month, in some part of the State. The total precipitation has been very unevenly distributed. In many of the eastern

(*Jour. Frank. Inst., Vol. CXXV. Feb., 1888.*)

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Service for Dece

County.	Station.	Elevation above Sea Level (feet).	Barometer.			Temperature.												Relative Humidity.	Dew Point.	Precipitation.			Numbe
							Maximum.		Minimum.				Daily Range.										
			Mean.	Highest.	Lowest.	Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.	Least.	Date.			Total Inches.	Total Depth of Snow (inches).	Number of Days Rainfall.	Clear.
Allegheny,	Pittsburgh,	766	30·088	30·860	29·530	36·3	61·5	4	7·5	29	43·2	28·8	14·4	33·5	28	4·3	4	71·1	27·3	1·99	. . .	14	4
Bedford,	Charlesville,	1,500	. . .	. . .	. . .	29·5	54·0	11	7·0	29	30·3	22·4	16·9	28·0	6	7·0	29	78·9	23·5	2·54	4·5	8	6
Blair,	Hollidaysburg,	947	. . .	. . .	. . .	30·5	54·0	11	7·0	22	38·3	21·4	16·9	27·0	6	7·0	22	74·0	22·6	2·83	. . .	7	10
Bradford,	Wysox,	718	. . .	. . .	. . .	31·2	57·5	11	0·5	31	38·8	23·6	15·2	25·5	20	6·0	22	78·5	25·0	3·08	16·0	12	3
Bucks,	Quakertown,	526	30·149	30·926	29·423	29·8	57·7	11	3·0	26	39·1	21·3	17·8	27·0	7	4·7	11	84·8	38·0	6·05	22·2	12	7
Centre,	Phillipsburg,	1,350	. . .	. . .	. . .	29·8	58·0	13	0·0	1	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1·77	25·6	13	9
Centre,	State College,	1,191	30·200	31·031	29·536	29·7	52·5	11	3·0	29, 30	39·4	20·4	19·0	23·0	14	8·5	15	89·6	27·0	2·25	14·6	7	4
Chester,	West Chester,	455	30·136	30·930	29·346	32·7	57·0	11	11·0	1	39·2	26·2	13·0	24·0	28	4·3	15	75·0	25·7	6·81	. . .	14	9
Clarion,	Clarion,	1,479	. . .	. . .	. . .	28·7	54·0	4	4·0	29	37·7	. . .	. . .	. . .	. . .	. . .	. . .	87·4	24·8	1·49	4·0	10	4
Clearfield,	Grampian Hills,	1,100	. . .	. . .	. . .	28·0	50·0	4	6·0	1	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3·12	14·5	11	6
Columbia,	Catawissa,	480	. . .	. . .	. . .	33·2	56·5	11	10·0	1	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2·00	10·3	12	. . .
Crawford,	Meadville,	1,080	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Cumberland,	Carlisle,	480	. . .	. . .	. . .	33·7	55·1	8	13·5	1	39·2	28·3	10·9	25·0	6	2·5	26	. . .	. . .	3·80	8·8	14	9
Delaware,	Swarthmore,	190	30·136	30·898	29·521	33·8	51·7	11	12·0	1	40·2	26·9	13·3	23·4	28	1·7	11	78·2	27·0	5·25	10·0	8	9
Elk,	Ridgway,	1,400	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Erie,	Erie,	681	30·060	30·930	29·520	32·2	58·5	4	7·8	1	41·2	25·5	15·7	35·8	28	5·8	24	81·0	26·6	3·13	. . .	21	3
Fayette,	Uniontown,	1,000	30·069	30·722	29·538	36·8	65·0	4	8·0	29, 30	43·7	27·8	15·9	36·0	7	4·0	26	79·5	31·8	1·69	2·5	6	8
Franklin,	Chambersburg,	618	30·046	. . .	29·605	31·6	53·0	11	11·0	. 1	39·3	22·4	16·9	20·0	8	6·0	18	79·6	26·8	4·47	. . .	6	8
Fulton,	McConnellsburg,	875	. . .	. . .	. . .	32·1	59·0	11	10·0	29	41·6	24·4	17·2	27·0	14	8·0	29	80·6	27·2	2·92	5·0	9	8
Huntingdon,	Huntingdon,	690	. . .	. . .	. . .	31·4	59·0	27	6·5	1	43·0	20·6	22·4	32·5	27	11·0	20	. . .	. . .	1·68	8·8	7	11
Indiana,	Indiana,	1,350	. . .	. . .	. . .	31·9	59·2	4	5·0	29, 30	40·0	22·8	17·2	35·5	28	6·0	12	82·0	27·4	3·27	4·6	11	4
Lackawanna,	Scranton,	730	. . .	. . .	. . .	28·5	55·0	11	3·5	1	41·7	23·6	18·1	30·5	1	7·0	18	85·1	23·0	4·24	18·2	14	8
Lancaster,	Lancaster,	413	30·161	30·955	29·465	31·8	56·8	10	—3·8	29	39·5	23·2	16·3	26·8	7	6·5	15	77·3	25·3	4·69	16·5	12	6
Luzerne,	Drifton,	1,655	. . .	. . .	. . .	28·5	57·0	10	1·0	31	36·9	19·8	19·1	36·0	20, 28	4·0	11	. . .	. . .	3·91	20·0	10	5
Lycoming,	Williamsport,	540	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Mercer,	Greenville,	1,000	30·027	30·756	29·414	30·0	53·6	4	5·5	29	37·6	23·4	14·2	26·2	6	5·2	26	86·1	25·2	2·54	11·3	16	3
Montgomery,	Pottstown,	150	. . .	. . .	. . .	33·1	58·0	11	10·0	26	40·1	25·7	14·1	27·0	7	2·0	15	75·6	26·0	6·50	24·5	9	12
Northampton,	Bethlehem,	360	30·097	30·880	29·410	32·1	58·0	11	3·0	26	38·6	23·2	15·4	31·0	8	8·0	18, 21	79·3	27·0	5·11	22·0	8	. . .
Philadelphia,	Philadelphia,	117	30·133	30·933	29·343	36·9	58·9	10	14·5	29	43·8	30·4	13·4	26·2	28	6·9	11	71·4	27·8	5·06	8·8	11	6
Pike,	Blooming Grove,	. . .	. . .	. . .	. . .	29·1	57·0	10	3·0	25	35·7	26·2	9·5	30·0	25	2·0	21	. . .	. . .	5·80	31·0	7	. . .
Schuylkill,	Girardville,	1,030	. . .	. . .	. . .	32·4	54·0	10, 21	7·0	29	31·6	23·0	15·6	26·0	28	7·0	21	. . .	. . .	4·81	27·5	10	. . .
Somerset,	Somerset,	2,250	. . .	. . .	. . .	29·1	59·2	4	1·0	29	38·4	17·0	21·4	34·0	7	6·0	26	80·0	23·2	1·67	6·7	9	4
Tioga,	Wellsboro,	1,327	. . .	. . .	. . .	30·9	60·0	11	7·0	1	37·8	24·9	12·9	30·0	14	3·0	12	. . .	. . .	2·35	10·5	11	3
Washington,	Washington,	1,175	. . .	. . .	. . .	33·6	60·0	4	8·0	29, 30	39·7	25·6	14·1	25·5	10	5·0	22	. . .	. . .	1·83	. . .	9	2
Wayne,	Dyberry,	1,100	. . .	. . .	. . .	26·1	52·0	11	—6·0	31	33·5	16·7	16·8	30·0	25	8·0	16	. . .	. . .	4·19	22·0	14	6
Westmoreland,	Greensburg	1,075	. . .	. . .	. . .	32·7	64·0	4	10·0	29	41·7	23·8	17·9	30·0	7	5·0	29	78·8	25·5	2·30	. . .	12	3

ARY OBSERVERS OF THE PENNSYLVANIA STATE WEATHER SERVICE FOR DECEMBER, 1887.

TEMPERATURE.									PRECIPITATION.			NUMBER OF DAYS.			W
Mean of Maximum.	Mean of Minimum.	DAILY RANGE. Mean.	Greatest.	Date.	Least.	Date.	Relative Humidity.	Dew Point.	Total Inches.	Total Depth of Snow (inches).	Number of Days Rainfall.	Clear.	Fair.	Cloudy.	Prevailing Direc
43·2	28·8	14·4	33·5	28	4·5	4	71·1	27·3	1·99	. . .	14	4	11	16	
39·3	22·4	16·9	28·0	6	7·0	29	78·9	23·5	2·54	4·5	8	6	7	18	
38·3	21·4	16·9	27·0	6	7·0	22	74·0	22·6	2·83	. . .	7	10	6	15	
38·8	23·6	15·2	25·5	20	6·0	22	78·5	25·0	3·08	16·0	12	3	10	18	
39·1	21·3	17·8	27·0	7	4·7	11	84·8	28·0	0·05	22·2	12	7	14	10	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1·77	25·6	13	9	6	16	
39·4	20·4	19·0	23·0	14	8·5	15	89·6	27·0	2·25	14·6	7	4	7	20	
39·2	26·2	13·0	24·0	28	4·5	15	75·0	25·7	6·81	. . .	14	9	11	11	
37·7	. . .	. . .	. . .	. . .	. . .	. . .	87·4	24·8	1·49	4·0	10	4	6	21	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3·12	14·5	11	6	7	18	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2·00	10·3	12	. . .	. . .	. . .	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
39·2	28·3	10·9	25·0	6	2·5	26	. . .	. . .	3·80	8·8	14	9	8	14	
40·2	26·9	13·3	23·4	28	1·7	11	78·2	27·0	5·25	10·0	8	9	9	13	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
41·2	25·5	15·7	35·8	28	5·8	24	81·0	26·6	3·13	. . .	21	3	6	22	
43·7	27·8	15·9	36·0	7	4·0	26	79·5	31·8	1·69	2·5	6	8	14	9	
39·3	23·4	16·9	20·0	8	6·0	18	79·6	26·8	4·47	. . .	6	8	8	15	
41·6	24·4	17·2	27·0	14	8·0	29	80·6	27·2	2·92	5·0	9	8	9	14	
43·0	20·6	22·4	32·5	27	11·0	20	. . .	. . .	2·68	8·8	7	11	5	15	
40·0	22·8	17·2	35·5	28	6·0	12	82·0	27·4	3·27	4·6	11	4	9	18	
41·7	23·6	18·1	30·5	1	7·0	18	83·1	23·0	4·74	18·2	14	8	8	15	
39·5	23·2	16·3	26·6	7	6·5	15	77·3	25·3	4·69	16·5	12	6	13	12	
38·9	19·8	19·1	36·0	20, 28	4·0	11	. . .	. . .	3·91	20·0	10	5	14	12	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
37·6	23·4	14·2	26·2	6	5·2	26	86·1	25·2	2·54	11·3	16	3	7	21	
40·1	25·7	14·4	27·0	7	2·0	15	75·6	20·0	6·50	24·5	9	12	14	5	
38·6	23·2	15·4	31·0	8	8·0	18, 21	79·3	27·0	5·11	23·0	8	. . .	. . .	. . .	
43·8	30·4	13·4	26·2	28	6·9	11	71·4	27·8	5·06	8·8	11	6	14	11	
35·7	26·2	9·5	30·0	25	2·0	21	. . .	. . .	5·80	31·0	7	. . .	. . .	. . .	
35·6	23·0	15·6	26·0	28	7·0	21	. . .	. . .	4·91	27·5	10	. . .	. . .	. . .	
38·4	17·0	21·4	34·0	7	6·0	26	80·0	23·2	1·87	6·7	9	4	9	18	
37·8	24·9	12·9	30·0	14	3·0	12	. . .	. . .	2·35	10·5	11	3	10	18	
32·7	25·6	14·1	25·5	10	5·0	22	. . .	. . .	1·83	. . .	9	2	8	21	
33·5	16·7	16·8	30·0	25	8·0	16	. . .	. . .	4·19	22·0	14	6	7	18	
41·7	23·8	17·9	30·0	7	5·0	29	78·8	25·5	2·30	. . .	12	3	10	18	

ER, 1887.

Days.	Wind.		
Cloudy.	Prevailing Direction.	Lunar Halos.	Observers.
16	W	. . .	Oscar D Stewart, Sgt. Sig. Corps.
18	W	7, 14	Rev. A. Thos. G. Apple.
15	. . .	. . .	Prof. J. A. Stewart.
18	NW	. . .	Charles Beecher.
30	NW	19, 25	J. L. Heacock.
16	NW	. . .	L. Ray Morgan.
20	W	30	Prof. Wm. Frear.
11	NW	25,27,30	Jessie C. Green, D.D.S.
21	W	. . .	J. H. Apple, A.B.
18	SW	. . .	Nathan Moore.
. . .	. . .	7, 30	Wm. G. Yetter.
. . .	. . .	. . .	Prof. J. H. Montgomery.
14	S	23,25,29	J. E. Pague.
13	NW	. . .	Prof Susan J. Cunningham.
. . .	. . .	. . .	Joe Messinger.
22	S	. . .	Peter Wood, Sgt Sig. Corps.
9	SW	. . .	Wm. Hunt.
15	. . .	. . .	Miss Mary A. Ricker.
14	SW	23, 24	Thomas F. Sloan.
25	W	. . .	Prof. W. J. Swigart.
18	SW	. . .	Prof. Albert E. Maltby.
15	SW	. . .	T. F. Heebner, M.D.
22	W	23, 25	A. M. Schmidt, A.B.
22	NW	. . .	H. D. Miller, M.D.
. . .	. . .	. . .	E. H. Baker.
21	NW	. . .	Prof S. H. Miller.
5	NW	. . .	Charles Moore, D.D.S.
. . .	W	. . .	Lerch & Rice.
11	NW	25,27,30	Luther M. Dey, Sgt. Sig. Corps.
. . .	W	. . .	John Grathwohl.
. . .	. . .	. . .	E. C Wagner.
18	SW	. . .	W. M. Schrock.
28	SW	. . .	H. D. Deming.
21	NW	2, 7	Harrison Otis.
28	NW	22, 27	Theodore Day.
18	W	27	H. S. Brunot.

T. F. Townsend.
Sergeant Signal Corps, Assistant.

counties there was an excess of 100 per cent., while in the western ones it ranged from normal to a deficit of from thirty to fifty per cent.

The following are the greatest reported:

West Chester, 6·81 inches; Pottstown, 6·50 inches; Quakertown, 6·05 inches; Blooming Grove, 5·80 inches; Philadelphia, 5·06 inches. The least are: from Clarion, 1·49 inches; Oil City, 1·76 inches; Uniontown, 1·69 inches, and Meadville, 1·89 inches.

Several of the western counties report much inconvenience from the continued drought. Many wells and springs are dry, and water for stock and other purposes requiring it in large quantities, was transported from running streams.

Snows occurred from the middle to the last of the month in variable quantities, amounting to a total of about two feet in some of the northern and eastern counties.

Owing to its being closely followed by rains, the snow was soon melted, and did not cause much interference with, or interruption to, travel. In the wooded districts of the State, the snow has not been sufficient to enable the lumbermen to transport their logs and timber to the streams. This work is generally performed during December and January, and has frequently been accomplished by the snows of November.

The prevailing winds have been from the Northwest and Southwest, with an absence of severe gales. More than the usual number of cloudy days have been reported. The weather summary for the month shows the following: Cloudy, 16 days; fair, 9 days; clear, 6 days.

Lunar halos were reported on the 2d, 7th, 19th, 22d, 23d, 24th, 25th, 27th, 29th and 30th.

Presque Isle Bay (Erie harbor) was closed to navigation by ice on the 23d.

North branch of the Susquehanna River frozen over on the 29th.

Quite heavy ice in the Delaware River on the 29th, 30th and 31st.

North Branch Canal closed to navigation on the 10th inst., and the Lehigh Canal on the 28th.

T. F. T.

PRECIPITATION FOR DECEMBER, 1887.

	Bethlehem.	Blooming Grove.	Carlisle.	Chambersburg.	Charlesville.	Clarion.	Drifton.	Dyberry.	Erie.	Girardville.	Grampian Hills.	Greensburg.	Greenville.	Hollidaysburg.	Huntingdon.	Indiana.	Lancaster.	McConnellsburg.	Meadville.	Oil City.	Philadelphia.	Phillipsburg.	Pittsburgh.	Pottstown.	Quakertown.	Scranton.	Somerset.	State College.	Swarthmore.	Uniontown.	Washington.	Wellsboro.	West Chester.	Wyson.
1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2	..	..	..	..	..	..	.03	.13	.25	..	..	..	.08	..	..	..	..	..	.50	..	..	..	.02	..	..	..	..	..	..	..	..	..	..	..
3	..	..	..	..	..	.06	..	..	.08	..	.10	.08	.15	..	..	.31	..	..	..	.34	..	.01	.02	..	.04	..	.03	..	..	.06	..	..	.09
4	.26	..	..	..	.10	..	..	.04	.46	.39	.60	.28	.14	.47	..	.54	..	..	..	.10	..	.03	.14	..	..	..	.01	..	.04	.08	.20	..	.04
5	..	.20	.02	.37	..	.70	.31	.20	..	..	..	.15	.03	..	.23	.20	.35	.23	..	.38	.24	.08	..	.30	.27	.17	.16	.27	.09	.39	..	.37	..
6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
7	..	..	..	..	..	..	..	..	..	.08	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
8	.02	..	.11	.15	.06	..	..	..	..	..	..	.02	..	..	.04	..	..	.11	..	..	..	..	..	.07	.04	..	..	..	..	..	..	.02	..	..
9	.20	..	.01	..	..	..	..	..	..	.33	.20	.02	..	..	..	..	..	.01	..	..	..	..	.09	..	..	..	..	..	..	.03	..	..	.23	..
10	.93	..	.96	.80	.84	.35	.00	.66	.20	.79	.50	.44	.30	.77	.64	.60	.71	.62	..	.22	.74	.05	.39	1.70	.76	.53	.35	.57	.64	.30	.67	1.10	1.15	.29
11	..	1.30	.02	..	..	.01	.34	.40	.31	..	..	..	.13	..	..	..	.30	..	.17	.08	.77	.07	.03	..	.50	.22	..	..	1.34	..	.05	..	.86	.01
12	..	..	..	..	..	.06	..	.02	.06	..	.05	.04	.05	..	..	..	..	..	.02	.02	.02	.05	.01	..	..	.14	..	..	..	..	..	..	.01	..
13	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
14	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.01	..	..	..	..	..	..	..	..	..	..	..
15	.60	.60	.62	..	.36	.05	.38	.45	.04	.61	..	..	.01	.05	..	..	.56	.46	.03	..	.90	..	..	.70	.71	.52	..	..	.76	..	..	..	.92	.02
16	..	..	.01	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.02	..
17	..	..	.40	2.50	.12	..	.10	.05	.16	.63	.10	.07	.17	.10	.20	.05	.50	..	.20	..	.13	..	.23	..	..	.15	..	..	..	..	.21	.05	.55	.66
18	1.56	2.00	.03	..	..	.19	1.22	.85	.11	..	.05	.13	.04	..	.03	.10	.70	..	..	.01	.77	.30	.07	2.00	1.91	.60	.11	.15	.70	.21	..	.23	.77	..
19	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.02	..	..	..	..	..	..	..	..	..	..	..	..	..	..
20	.42	..	.42	..	.37	..	.12	.17	.22	.43	.45	.32	.01	.51	..	.35	.30	.49	..	..	.24	..	.08	.40	.12	.02	.10	..	..	..	..	.06	.41	.59
21	..	.30	.10	..	..	..	..	.20	.19	..	..	..	.18	..	.60	..	.20	.02	.02	.06	.08	.40	..	..	.32	.41	..	.40	.34	..	..	..	.20	.04
22	..	..	..	..	..	..	..	..	.13	..	..	..	.09	..	..	..	..	..	.02	..	..	.40	..	..	..	..	..	..	..	..	..	..	..	..
23	..	..	..	..	..	..	..	..	.01	..	..	..	..	..	..	..	..	..	..	..	..	.02	..	..	..	..	..	..	..	..	..	..	..	..
24	..	..	..	..	..	..	..	..	.04	..	..	..	.03	..	..	..	..	..	.10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
25	..	..	..	..	..	..	..	..	.05	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
26	..	.10	.06	..	..	.05	.06	.08	.06	.08	.06	..	.01	..	..	.05	.03	..	..	..	..	..	.02	..	.04	.07	..	.20	..	..	..	.05	.04	.13
27	..	..	..	.05	..	..	..	..	.02	..	..	..	..	..	..	..	.02	..	..	..	..	..	..	.03	.03	..	..	..	..	..	..	..	..	..
28	.82	1.00	.52	.60	.33	.02	.45	.62	.34	1.14	.41	.15	.13	.19	.30	.62	.63	.56	.20	.50	.92	.18	.14	.80	1.16	.66	.40	.26	1.28	..	.11	.32	1.18	.31
29	..	..	..	..	..	..	..	..	.06	..	..	..	.01	..	.29	.20	..	..	.25	.02	..	.04	.01	..	..	.12	.33	..	..	..	.06	..	..	..
30	..	..	..	..	..	..	..	..	.01	..	..	..	..	..	..	..	..	..	.10	.01	..	..	..	..	..	..	..	..	..	.17	..	..	..	..
31	..	.10	.52	..	.36	..	..	.32	.33	.43	.60	.60	.96	.74	.35	.25	.40	.42	.28	..	.25	.14	.20	.50	.18	.60	.38	.40	.10	.58	.56	.35	.31	.66
	3.11	5.80	3.80	4.47	2.54	1.49	3.91	4.19	3.13	4.91	3.12	2.30	2.54	2.83	2.68	3.27	4.69	2.92	1.89	1.76	3.06	1.77	1.99	6.50	6.03	4.24	1.87	2.25	5.25	1.09	1.83	2.35	6.81	3.08

T. F. 1.

PENNSYLVANIA STATE WEATHER SERVICE BULLETIN FOR JANUARY, 1888.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 31, 1888.

The new year's report shows a very creditable increase of stations over the last, but it will not be complete until every county in the State is represented. Observers are wanted in the following counties: Adams, Beaver, Cambria, Carbon, Greene, Jefferson, Juniata, Lehigh, Mifflin, Potter, Snyder, Union and Wyoming. The value of reliable records of the climate of every portion of the State is apparent, and the opportunity to secure the standard instruments, which the Committee holds for the counties above named, should not be neglected by them.

The Committee has received numerous applications for instruments for additional observation stations in the counties already supplied, but is unable to grant them without crippling its ability to supply each county in the State as provided by law.

Those having instruments of their own, who desire to join the Service, will be gladly welcomed, suitable forms and instructions furnished them, and their reports published. The State Service was organized for the benefit of the people of Pennsylvania. The larger the force of observers and displaymen, the greater will be the facilities to accomplish its purposes. Observers are particularly requested to provide substitutes to take their observations during times when they cannot attend to them, so that their records may be complete and continuous.

The editors of papers and the various organized associations throughout the State are earnestly requested to assist the Service in obtaining observers and displaymen.

The taking of observations is a pleasant pastime for ladies, and those already in the service have shown a remarkable aptitude for the work.

The Chief Signal Officer has made arrangements to telegraph the indications and cold-wave warnings to those who will display the Weather Signal Flags. Where the displayman can have access to the Bulletins displayed at Railway Stations, no special telegraphic advices will be required for the indications. The necessary arrangements will be made for this information by the State Service, on application addressed to Sergeant T. F. Townsend, State Weather Service, Philadelphia. The State Service will furnish flags to a few selected stations.

The Committee desires to acknowledge its obligations to the following railroad companies for facilities offered:

The Pennsylvania Railroad Company.

The Philadelphia and Reading Railroad Company.

The Lehigh Valley Railroad Company.

The Committee on Meteorology of the FRANKLIN INSTITUTE,
W. P. TATHAM, *Chairman.*

REVIEW FOR JANUARY, 1888.

TEMPERATURE.

The characteristics of January, 1888, were the distinctive thermal periods of abnormal warmth and cold, dividing the month into two equal parts.

The mean daily temperatures, as compared with the mean daily temperatures deduced from the records of fifteen years, show a daily excess of about 5° during the first half of the month, and a daily deficiency of about 10° during the last half. At the end of the month there was a total deficiency of temperature amounting to 49° at Pittsburgh, 106° at Philadelphia, and 179° at Erie.

The mean temperature for the month was 22°.1, which is probably 5° below the normal.

The highest temperatures occurred on the 1st and 7th, and ranged from 61° at Pittsburgh, to 40°.5 at Carlisle.

The lowest temperatures were on the 22d and 23d, and the following were noted: Dyberry,—19°; Wellsboro,—16°; Columbus,—15°; Eagles Mere,—14°; Greenville,—14°, and Clarion,—13°.5.

The mean maxima temperatures for the month was 30°.2, and the mean minima 16°.3. These show a daily mean of 23°.2, which is 1°.1 above that obtained from the tri-daily observations at 7 A. M., 2 P. M., and 9 P. M.

ATMOSPHERIC PRESSURE.

The mean barometric pressure was nearly .08 above the normal.

The lowest pressure (29.49 at Erie) occurred on the 1st. This depression was attended with the highest temperatures and the heaviest rainfall of the month.

The second low pressure was during the snowstorm of the 25th and 26th, and was followed by high Northwest winds, which drifted the snow and caused serious blockades.

A high pressure on the 11th and 12th was attended by low temperatures and generally fair weather. The unusual and extreme high barometer, 30.86 at Erie, 30.83 at Philadelphia, and 30.820 at Pittsburgh, occurred on the 16th, and heralded the cold period which prevailed from that date to the end of the month.

The third high pressure had for its escort the extreme cold of the 22d and 23d.

PRECIPITATION.

The precipitation for the month amounted to an average of 4.19 inches, which is nearly one inch in excess of the monthly average. Of this amount (4.19 inches) 1.40 inches was melted snow and hail. The rain and snowfall was very unevenly distributed, and ranged from 6.75 inches at Indiana, 6.17 inches at Pittsburgh, 6.04 inches at Huntingdon, to 2.12 inches at Chambersburg. Excepting the 14th and 22d rain or snow fell in measurable quantities on every day on some part of the State. The greatest amount, and the most rainy days, occurred in Western Pennsylvania. Most of the storms were mixtures of rain, snow and sleet.

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Ser

County.	Station.	Elevation above Sea Level (feet).	Barometer.			Temperature.												Relative Humidity.	Dew Point.	
							Maximum.		Minimum.				Daily Range.							
			Mean.	Highest.	Lowest.	Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean	Greatest.	Date.	Least.	Date.			
Allegheny,	Pittsburgh,	847	30·183	30·820	29·610	28·6	61·0	7	3·0	28	36·0	20·3	15·7	27·5	1	6·3	9	71·2	20·7	6
Armstrong,	Kittanning,																			
Bedford,	Charlesville,	1,500				22·9	53·0	7	—7·5	12	30·2	14·0	16·2	29·5	13	7·0	9	77·1	16·8	4
Berks,	Reading— Selwyn Hall School,																			
Berks,	Kutztown— Keystone State Normal School,																			
Blair,	Hollidaysburg,	947				22·7	49·0	7	—5·0	23	32·5	13·4	19·1	35·0	13	8·0	6	73·5	15·6	5
Bradford,	Wysox,	718				21·4	48·3	1	—6·0	22	28·9	13·9	15·0	27·5	23	10·5	28	76·6	14·6	2
Bucks,	Quakertown,	536	30·200	30·840	29·610	21·8	49·7	1	—4·2	23	30·6	13·5	17·1	29·7	1	9·5	6, 31	85·6	18·3	4
Butler,	Butler,																			
Cameron,	Emporium,																			
Centre,	State College— Agricultural Experiment Station,	1,191	30·210	30·857	29·814	21·1	47·0	7	—9·0	23	27·9	10·2	17·7	27·5	23	8·0	9	85·9	18·0	3
Centre,	Phillipsburg,	1,350				21·4	52·0	7	—10·0	21, 22	30·4	12·4	18·0							3
Chester,	West Chester,	455	30·199	30·811	29·613	24·6	50·0	1	0·0	22	31·2	17·4	13·8	26·0	16	5·0	6			5
Chester,	Coatesville,																			
Clarion,	Clarion— State Normal School,	1,479				19·8	49·0	1	—13·5	22	28·2	11·4	16·8	32·5	22	7·0	11	89·4	17·3	4
Clearfield,	Grampian Hills,	1,450	30·028	30·598	29·608	19·2	54·0	7	—12·0	22	24·8	12·1	12·7	28·0	23	1·0	18			5
Clinton,	Lock Haven— Central State Normal School,																			
Columbia,	Catawissa,	480				22·3	50·0	1	—5·5	22, 23										3
Crawford,	Meadville— Allegheny College,	1,252				23·2	54·0	7	—9·5	22	30·0	12·1	17·9	36·0	13	4·0	26	69·0	14·6	4
Cumberland,	Carlisle— Dickinson College,																			
Cumberland,	Carlisle,	480				20·3	40·5	8	1·0	23										3
Dauphin,	Harrisburg,																			
Delaware,	Swarthmore— Swarthmore College,	190	30·176	30·847	29·678	23·8	53·3	1	2·0	22	31·5	18·2	13·3	28·7	1	5·0	6	76·4	19·8	4
Elk,	Ridgway,																			
Erie,	Erie,	681	30·192	30·860	29·490	21·0	55·0	7	—6·0	22	31·6	13·4	18·2	34·0	13	7·0	28	83·0	16·0	2
Fayette,	Uniontown,	1,000	30·136	30·623	29·623	30·4	60·0	6, 7	2·0	22	39·0	22·4	16·6	27·0	4	3·0	8	76·2	22·5	5
Forest,	Tionesta,																			
Franklin,	Chambersburg— Wilson Female College,	618	30·237	30·830	29·786	22·8	43·5	3	—1·0	23	32·0	15·4	16·6	28·0	15	8·0	6, 7	75·6	16·0	2
Fulton,	McConnellsburg,	875				24·3	47·0	8	2·0	12, 22	33·0	16·5	16·5	28·0	30	6·0	18	78·2	18·4	4
Huntingdon,	Huntingdon— The Normal College,	650				22·0	47·0	1	7·5	22, 23	32·0	14·1	17·9	31·0	14	7·0	7	86·5	19·1	6
Indiana,	Indiana— State Normal School,	1,350				23·8	58·0	7	—5·5	22	32·3	13·7	18·6	47·0	13	7·0	18, 31	88·1	21·0	6
Lackawanna,	Scranton,	750				20·6	50·0	1	—6·0	23	29·8	12·8	17·0	27·0	11, 13	9·5	26	82·1	15·2	4
Lancaster,	Lancaster— Franklin and Marshall College,	413	30·227	30·833	29·733	23·6	47·0	1	—5·0	22	31·1	16·1	15·0	24·5	30	6·5	17	77·8	16·8	4
Lawrence,	New Castle,	930				23·1	54·0	7	—12·0	29	31·0	14·7	16·3	32·0	29	3·0	8	87·3	20·1	9
Lebanon,	Lebanon,*	480				18·7	40·8	14	—3·5	23	26·0	10·8	15·2	28·9	20	6·3	17	75·5	12·7	1
Luzerne,	Drifton— Drifton Hospital,	1,655				18·3	44·0	15	—10·0	22	29·8	9·9	19·9	30·0	13	11·0	3			3
Lycoming,	Williamsport,																			
McKean,	Smethport,																			
Mercer,	Greenville— Thiel College,	1,000	30·142	30·909	29·483	20·4	53·6	7	—14·0	29	29·6	12·0	17·6	31·5	23	4·2	19	84·7	15·2	3
Monroe,	Stroudsburg,																			
Montgomery,	Pottstown,	150				24·3	47·0	1	0·0	22	30·0	19·1	10·9	21·0	20	5·0	6	74·5	16·8	4
Northampton,	Bethlehem,	300	30·242	30·678	29·641	23·0	52·0	1	—4·0	23	29·0	16·0	13·0	31·1	1	4·0	31	73·0	15·8	5
Northumberland,	Shamokin,	733				22·2	50·0	1	—6·0	23	31·7	15·3	17·4	29·0	23	10·0	1, 19	81·0	17·8	3
Perry,	New Bloomfield,	400				22·5	44·0	1	—10·0	23	29·2	15·8	13·4	33·0	20	4·0	18			2
Philadelphia,	Philadelphia,	127	30·202	30·830	29·620	28·0	56·2	1	2·4	22	35·4	20·2	15·2	29·0	11	8·3	9	71·4	19·3	4
Pike,	Blooming Grove,	800				19·4	49·0	7	—12·0	23										2
Schuylkill,	Girardville,	1,030	30·137	30·701	29·713	23·5	47·0	1	—4·0	23	29·9	12·8	17·1	33·0	13	5·0	31			3
Somerset,	Somerset,	2,250				22·2	56·0	7	—13·0	22	34·2	12·3	21·9	38·0	22	7·0	28	85·0	19·0	6
Sullivan,	Eagles Mere,	2,060				13·6	40·0	1	—14·0	22	19·6	7·0	12·6	24·0	25	4·0	9, 11, 26	68·7	3·2	6
Sullivan,	Bernice,†	2,300				15·6	46·0	7	—11·0	22	23·8	7·3	16·5	28·0	23	7·0	19	83·9	11·6	2
Susquehanna,	Montrose,																			
Tioga,	Wellsboro,	1,327	30·180	30·804	29·679	20·6	50·0	7	—16·0	22	26·5	13·5	13·0							3
Washington,	Scenery Hill,																			
Washington,	Washington,	1,175				24·4	54·8	1	1·5	28	29·8	16·7	13·1	25·0	4	1·0	18			5
Warren,	Columbus,	1,410	30·445	30·986	29·730	17·9	49·0	7	—15·0	22	25·3	10·5	14·8	45·0	22	1·0	8, 26			3
Wayne,	Dyberry,	1,100				15·5	44·5	1	—19·0	23	24·8	4·8	20·0	34·0	23	3·5	9			4
Westmoreland,	Greensburg,	1,075				26·8	57·8	1	—0·5	22	35·5	13·5	22·0	25·8	1	9·0	16	82·2	21·8	5
York,	York,	385				24·4	43·0	1	3·0	22	31·3	17·5	13·8	25·0	16, 20	4·5	31	75·6	17·5	2

* From February 3d.

† From February 11th.

Voluntary Observers of the Pennsylvania State Weather Service for January

Temperature.									Relative Humidity.	Dew Point.	Precipitation.			
Minimum.		Mean of Maximum.	Mean of Minimum.	Daily Range.										
Lowest.	Date.			Mean.	Greatest.	Date.	Least.	Date.			Total Inches.	Total Depth of Snow (inches).	Number of Days Rainfall.	
3·0	28	36·0	20·3	13·7	27·5	1	6·3	9	71·2	20·7	6·17	9·4	22	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
—7·5	12	30·2	14·0	16·2	29·5	13	7·0	9	77·1	16·8	4·06	9·5	11	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
—5·0	23	32·5	13·4	19·1	35·0	13	8·0	6	73·5	15·6	5·69	16·5	21	
—6·0	22	28·9	13·9	15·0	27·5	23	10·5	28	76·6	14·6	2·63	13·0	7	
—4·2	23	30·6	13·5	17·1	29·7	1	9·5	6, 31	83·6	18·3	4·45	15·5	14	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
—9·0	23	27·9	10·2	17·7	27·5	23	8·0	9	85·9	18·0	3·46	17·3	13	
—10·0	21, 22	30·4	12·4	18·0	. . .	. . .	. . .	. . .	. . .	. . .	3·52	14·0	14	
0·0	22	31·2	17·4	13·8	26·0	16	5·0	6	. . .	. . .	5·69	. . .	17	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
—13·5	22	28·2	11·4	16·8	32·5	22	7·0	31	89·4	17·3	4·88	12·5	13	
—12·0	22	24·8	12·1	12·7	28·0	23	1·0	18	. . .	. . .	5·77	20·0	15	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
—5·5	22, 23	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3·58	10·8	14	
—9·5	22	30·0	12·1	17·9	36·0	13	4·0	26	69·0	14·6	4·49	30·5	14	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
1·0	23	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	3·30	10·5	13	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
2·0	22	31·5	18·2	13·3	28·7	1	5·0	6	76·4	19·8	4·37	—	12	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
—6·0	22	31·6	13·4	18·2	34·0	13	7·0	28	83·0	16·0	2·79	13·0	24	
2·0	22	39·0	22·4	16·6	27·0	4	3·0	8	70·2	22·5	5·69	5·5	9	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
—1·0	23	32·0	15·4	16·6	28·0	15	8·0	6, 7	75·6	16·0	2·12	13·0	8	
2·0	12, 22	33·0	16·5	16·5	28·0	30	6·0	18	78·2	18·4	4·32	10·5	12	
7·5	22, 23	32·0	14·1	17·9	31·0	14	7·0	7	86·5	19·1	6·04	11·7	12	
—5·5	22	32·3	13·7	18·6	47·0	13	7·0	18, 31	88·1	21·0	6·75	13·4	17	
—6·0	23	29·8	12·8	17·0	27·0	11, 13	9·5	26	82·1	13·2	4·30	14·8	13	
—5·0	22	31·1	16·1	15·0	24·5	30	6·5	17	77·8	16·8	4·79	15·2	13	
—12·0	20	31·0	14·7	16·3	32·0	29	1·0	8	87·3	20·1	2·77	4·7	13	
—3·5	23	26·0	10·8	15·2	28·9	20	6·3	17	75·5	19·7	1·64	11·9	8	
—10·0	22	29·8	9·9	19·9	30·0	13	11·0	3	. . .	. . .	3·79	. . .	9	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
—14·0	29	29·6	12·0	17·6	31·5	23	4·2	19	84·7	15·2	3·50	11·4	21	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
0·0	22	30·0	19·1	10·9	21·0	20	5·0	6	74·5	16·8	4·31	—	10	
—4·0	23	25·0	16·0	13·0	31·1	1	4·0	31	73·0	15·8	5·09	. . .	8	
—6·0	23	32·7	15·3	17·4	29·0	23	10·0	1, 19	81·0	17·2	2·57	8·2	11	
—10·0	23	29·2	15·8	13·4	33·0	20	4·0	18	. . .	. . .	2·47	12·8	9	
2·4	22	35·4	20·2	15·2	29·0	11	8·3	9	71·4	19·3	4·30	6·5	15	
—12·0	23	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2·90	19·0	13	
—4·0	23	29·9	12·8	17·1	33·0	13	5·0	31	. . .	. . .	3·50	11·8	9	
—13·0	22	34·2	12·3	21·9	38·0	22	7·0	28	85·0	19·0	6·40	25·8	16	
—14·0	22	19·6	7·0	12·6	24·0	25	4·0	9, 11, 26	68·7	5·2	6·16	41·3	12	
—11·0	22	23·8	7·3	16·5	28·0	23	7·0	19	83·9	11·6	2·95	16·2	14	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
—16·0	22	26·5	13·5	13·0	. . .	. . .	. . .	. . .	. . .	. . .	3·70	16·9	11	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
1·5	28	29·8	16·7	13·1	25·0	4	1·0	18	. . .	. . .	5·56	—	11	
—15·0	22	25·3	10·5	14·8	45·0	22	1·0	8, 26	. . .	. . .	3·32	—	19	
—19·0	23	24·8	4·8	20·0	34·0	23	5·5	9	. . .	. . .	4·38	18·2	16	
—0·5	22	35·5	13·5	22·0	25·8	1	9·0	16	82·2	21·8	5·06	10·6	14	
3·0	22	31·3	17·5	13·8	25·0	16, 20	4·5	31	75·6	17·5	2·70	7·3	7	

OR JANUARY, 1888.

TATION.		NUMBER OF DAYS.			WIND.	
Snow (inches).	Number of Days Rainfall.	Clear.	Fair.	Cloudy.	Prevailing Direction.	OBSERVERS.
'4	22	2	10	19	W	Oscar D Stewart, Sgt. Sig. Corps.
.	. . .	. . .	. . .	. . .	. . .	Tyson Heilman.
'5	11	5	11	15	NW	Rev. A. Thos. G. Apple.
.	. . .	. . .	. . .	. . .	. . .	Prof. George A. Ruddle.
.	. . .	. . .	. . .	. . .	. . .	Prof. J. H. Rohrbach.
'5	11	5	15	11	W	Prof. J. A. Stewart.
'0	7	7	8	16	NW	Charles Beecher.
'3	14	4	17	10	NW	J. L. Heacock.
.	. . .	. . .	. . .	. . .	. . .	J. E. Forsythe.
.	. . .	. . .	. . .	. . .	. . .	A. H. Boynton.
'3	13	3	13	15	W	Prof. Wm. Frear.
'0	14	3	10	18	SW	L. Ray Morgan.
.	17	11	10	10	NW	Jessie C. Green, D.D.S.
.	. . .	. . .	. . .	. . .	. . .	W. T. Gordon.
'5	13	3	9	19	W	J. H. Apple, A.B.
'0	15	2	9	19	W	Nathan Moore.
.	. . .	. . .	. . .	. . .	. . .	Prof. Wallace P. Dick.
'8	14	. . .	. . .	. . .	. . .	Wm. G. Yetter.
'3	14	3	9	19	W	Prof. J. H. Montgomery.
.	. . .	. . .	. . .	. . .	. . .	Charles F. Himes, Ph.D.
'5	13	7	11	13	—	J. E. Pague.
.	. . .	. . .	. . .	. . .	. . .	Zenos J. Gray, M.D.
.	12	9	10	12	N	Prof Susan J. Cunningham.
.	. . .	. . .	. . .	. . .	. . .	Joe Messinger.
'0	24	1	10	20	NW	Peter Wood, Sgt Sig. Corps.
'3	9	3	12	14	SW	Wm. Hunt.
.	. . .	. . .	. . .	. . .	. . .	Robert L. Haslet.
'0	8	8	11	12	—	Miss Mary A. Ricker.
'5	12	8	10	13	W	Thomas F. Stoan.
'7	12	13	8	10	W	Prof. W. J. Swigart.
'4	17	3	9	19	SW	Prof. Albert E Maltby.
'8	13	9	10	12	W	T. F. Heebner, M.D.
'9	13	5	13	13	W	A. M. Schmidt, A.B.
'7	13	4	11	16	NW	Wm. T. Butz.
'9	8	6	8	7	NW	George W. Hayes, C.E., Ph G.
.	9	. . .	. . .	. . .	. . .	H. D. Miller, M.D.
.	. . .	. . .	. . .	. . .	. . .	E. H. Baker.
.	. . .	. . .	. . .	. . .	. . .	Armstrong & Brownell.
'4	21	1	9	21	NW	Prof. S. H. Miller.
.	. . .	. . .	. . .	. . .	. . .	N. C. Miller, M.D
.	10	9	11	11	NW	Charles Moore, D.D.S.
.	8	. . .	. . .	. . .	W	Lerch & Rice.
'2	11	5	14	12	NW	G. R. Hanley.
'8	9	11	9	11	W	Frank Mortimer.
'5	15	6	14	11	NW	Luther M. Dey, Sgt. Sig. Corps.
'0	15	. . .	. . .	. . .	W	John Grathwohl.
'8	9	9	10	12	NW	E. C Wagner.
'8	16	5	8	18	NW	W. M. Schrock.
'3	12	3	11	17	NW	E. S. Chase.
'2	14	3	11	15	N	C. R. Claghorn.
.	. . .	. . .	. . .	. . .	. . .	A. H. Berlin.
'9	11	2	6	23	N	H. D. Deming.
.	. . .	. . .	. . .	. . .	. . .	Jacob Gayman.
-	11	4	5	15	NW	Harrison Otis.
-	19	2	4	25	SW	Wm. Loveland.
'2	16	6	7	18	NW	Theodore Day.
'6	14	2	11	18	W	H. S. Brunot.
'3	7	9	10	12	NW	Mrs. L. H. Grenewald.

T. F. TOWNSEND,
Sergeant Signal Corps, Assistant.

PRECIPITATION FOR JANUARY, 1888.

	Erie.	Meadville.	Greenville.	New Castle.	Pittsburgh.	Columbus.	Clarion.	Greensburg.	Uniontown.	Indiana.	Somerset.	Grampian Hills.	Phillipsburg.	Hollidaysburg.	Charlesville.	State College.	Huntingdon.	McConnellsburg.	Chambersburg.	New Bloomfield.	Carlisle.	York.	Wyson.	Eagles Mere.	Bernice.†	Shamokin.	Girardville.	Lebanon.*	Lancaster.	Scranton.	Pottstown.	West Chester.	Dyberry.	Blooming Grove.	Quakertown.	Swarthmore.	Philadelphia.
1	.52	. .	.42	.02	.67	.60	. .	. .	.57	1.01	1.24	.83	.84	1.07	1.30	.57	2.00	1.69	. .	1.06	1.39	1.40	.06	.30	.10	.50	1.25	. .	1.60	1.25	1.50	2.22	1.70	.30	1.65	2.02	1.58
2	.04	. .	.10	. .	. .	. .	. .	. .	. .	. .	. .	. .	.06	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.02	.01	. .	. .	. .	.50	. .	. .	.08	. .	. .	.09	.08	.07
3	.06	.15	. .	. .	.12	.05	.50	. .	. .	. .	.15	. .	.04	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.01	. .	. .	. .	.05	. .	. .	. .	. .	.02	. .	. .
4	.05	. .	. .	. .	. .	.02	. .	. .	. .	. .	. .	. .	.01	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.05	. .	. .	. .	. .
5	.03	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.04	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
6	.62	.95	.98	.50	.68	.67	.72	.65	.81	1.10	.97	.71	.18	.95	.27	.20	.33	.12	.15	.01	.12	.04	1.13	.34	.60	.32	.53	. .	.25	.65	.40	.13	.32	.10	.17	. .	.10
7	.24	. .	.50	.75	.89	.28	.83	.73	.68	1.41	.43	.74	.73	.31	.22	.54	.44	.33	.27	.06	.16	.21	.13	. .	.13	.22	.37	. .	.02	. .	.25	.09	.06	. .	.21	.22	.06
8	.18	. .	.10	.18	.38	.13	.14	.43	.47	.33	.31	.20	. .	. .	.09	.32	.42	.11	.15	.06	.03	.15	. .	. .	.16	.33	. .	. .	.10	.22	. .	.36	.19	.30	.11	.22	.17
9	. .	. .	.01	. .	.05	. .	. .	.61	. .	.05	.13	. .	. .	.15	. .	. .	.13	.19	.05	.05	.01	. .	. .	. .	. .	. .	.09	. .	.60	.08	. .	.09	. .	. .	. .	.08	.03
10	.06	.14	.02	.02	.17	.65	.15	.15	.32	.15	.07	.15	.36	. .	. .	.13	. .	. .	. .	. .	.03	. .	. .	.31	.07	. .	. .	. .	.11	.08	.25	.31	.18	.30	.20	.29	.20
11	. .	.25	.08	. .	.02	.03	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
12	.15	. .	. .	.05	.10	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.90	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
13	.04	.10	.36	.40	.85	.32	.73	.87	.67	.42	1.18	.90	.06	1.28	1.38	.66	1.40	.10	.50	.45	.72	.30	. .	2.17	.52	.30	.41	.65	.70	.68	.40	1.11	.45	.30	.70	.92	.97
14	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
15	.15	.30	.34	.47	.80	.29	.63	.56	.71	.86	.25	.77	1.08	.22	.03	.27	.03	.05	. .	. .	.01	.08	. .	.63	.42	.35	.18	.10	.10	.32	.08	.12	.40	.40	.09	.02	.16
16	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.01	.10	. .	. .	. .	. .	. .	.08	. .	. .	. .	. .	. .
17	.15	.10	.19	. .	.23	.22	. .	.35	.27	.05	. .	.33	. .	.44	.26	.10	.43	.23	.32	.20	.18	. .	.68	.33	.30	. .	.24	.18	.09	.20	.38	.37	.29	. .	.18	.01	.20
18	.08	.15	.01	.05	.09	.02	.30	.10	.07	.05	.25	.05	. .	. .	. .	.01	.25	. .	. .	. .	.02	. .	. .	.23	.15	. .	. .	. .	. .	.25	. .	.02	. .	.40	.25	. .	. .
19	.03	.30	.03	. .	.17	.02	. .	. .	. .	. .	.13	. .	.02	. .	.02	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.05	. .	. .	. .	. .	. .
20	.03	.15	.03	.06	.08	.03	.06	.02	.05	.17	.01	.10	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
21	. .	. .	.01	. .	.03	. .	. .	. .	.05	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
22	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
23	.04	. .	.04	.08	.03	.03	.10	.01	. .	.05	. .	. .	.04	.05	. .	.01	. .	. .	. .	. .	. .	. .	. .	.08	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
24	.02	.30	.01	. .	. .	.03	. .	. .	. .	.05	. .	.05	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.04	. .	. .	. .	. .
25	.18	.60	.21	.15	.46	.22	.12	.03	.42	.60	.45	.30	. .	1.07	.31	.50	.50	.35	.45	.50	.48	.52	.40	1.30	.30	.30	.43	.59	.60	.40	.90	.80	.30	. .	.61	.72	.53
26	.02	.50	.06	.04	.08	.30	.50	.53	.10	.25	.51	.44	.04	. .	. .	. .	. .	. .	. .	. .	.05	. .	.10	.40	.05	.13	. .	. .	. .	.20	. .	.03	.50	.80	.05	. .	.06
27	.08	.50	.05	. .	.16	. .	. .	.02	.15	. .	.10	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.04	. .	. .	. .	. .	.01
28	.01	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.04	. .	. .	. .	. .	. .
29	. .	. .	.01	. .	. .	. .	.10	. .	. .	. .	. .	.16	. .	.01	.06	.08	.06	.15	.23	.08	.10	. .	. .	. .	. .	. .	. .	.05	.02	. .	. .	.03	. .	. .	. .	. .	.02
30	. .	. .	. .	. .	.01	. .	. .	. .	. .	.01	. .	. .	.06	. .	. .	. .	. .	. .	. .	. .	. .	. .	.13	. .	. .	. .	. .	.01	. .	. .	. .	. .	. .	. .	. .	. .	. .
31	.01	. .	. .	. .	.10	.01	. .	. .	.35	.19	.22	. .	. .	.14	.12	.07	.05	.10	. .	. .	. .	. .	. .	.05	.13	.01	. .	.06	.10	.10	.15	.11	.07	. .	.12	.05	.14
	2.79	4.49	3.50	2.77	6.17	3.32	4.88	5.06	5.69	6.75	6.40	5.77	3.52	5.69	4.04	3.46	6.04	4.32	2.12	2.47	3.30	2.70	2.63	6.16	2.95	2.57	3.50	1.64	4.79	4.36	4.31	5.89	4.38	2.90	4.45	4.57	4.30

* From February 3d. † From February 11th.

T. F. T.

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SNOWFALL.

The total depth of snowfall (unmelted) during the month, averaged 14 inches. Eagles Mere reports 41 inches; Meadville, 31 inches; Blooming Grove, 19 inches; Dyberry, 18 inches; Wellsboro, 17 inches, and Bernice, 16 inches. The snowfall of the 25th ranged from 6 to 12 inches, where the blockades occurred. The snow was fine and dry, and was followed by high Northwest winds, which drifted it until many of the country roads were "fence full," and the railroad cuts rendered impassable. Several trains were delayed for hours, some had to be dug out, and several teamsters were obliged to abandon their wagons on the road. The obstruction caused by drifts is said to have been the worst for years, in many parts of the State, and travel for a time was almost suspended.

WIND AND WEATHER.

Prevailing direction, Northwest.

Average number of clear days, 5; fair days, 11; cloudy days, 15; rainy days, 13.

MISCELLANEOUS PHENOMENA.

Auroras.—Eagles Mere, 8th; Clarion, 11th; Indiana, 13th; Greenville, 13th; Bernice, 13th; Charlesville, 13.

Solar Halos.—Charlesville, 3d; Eagles Mere, 12th, 16th, 20th, 22d, 23d, 24th, 25th, 28th; Wellsboro, 12th, 15th; Quakertown, 23d; West Chester, 25th; Dyberry, 25th.

Parhelias.—Eagles Mere, 20th; Dyberry, 27th, 28th.

Lunar Halos.—Philadelphia, 2d, 24th; Pottstown, 18th; West Chester, 19th, 24th, 25th; Indiana, 19th, 20th; Catawissa, 19th, 24th, 25th; Wellsboro, 19th, 26th; Bernice, 19th; Greensburg, 19th; Eagles Mere, 19th, 27th; Somerset, 20th, 24th; Carlisle, 22d, 24th; Dyberry, 23d, 24th, 28th; Scranton, 23d; Quakertown, 24th; Clarion, 24th; Lebanon, 24th; Lancaster, 24th; Greenville, 24th; Shamokin, 24th.

Lunar Coronæ.—Huntingdon, 20th; Lebanon, 20th; Greensburg, 25th; Greenville, 27th; Indiana, 27th.

REMARKS.

The ice harvest was a prolific one and good crops have been secured. Winter wheat has been well protected and is in good condition.

WEATHER SIGNALS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
Chester Oil Company,	Chester.

Displayman.	*Station.*
C. W. Burkhart,	Shoemakerville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Werner & Son,	Emporium.
C. E. Lenhart,	Latrobe.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
S. W. Morrison,	Oxford.
Capt. A. Goldsmith,	Quakertown.
J. L. Morrison,	Sharon.
Wm. A. Engel,	Shenandoah.
Wm. Schrock,	Somerset.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
E. H. Baker,	Williamsport.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
E. S. Chase,	Eagles Mere.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
Armstrong & Brownell,	Smethport.
J. E. Forsythe,	Butler.
James H. Fones,	Tionesta.
Wister, Hacker & Savage,	Germantown.
W. J. Thompson & Co.,	Clifton Heights.
Steward M. Dreher,	Stroudsburg.
State Normal School,	Millersville.
E. C. Wagner,	Girardville.

PENNSYLVANIA STATE WEATHER SERVICE BULLETIN FOR FEBRUARY, 1888.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, February 29, 1888.

Two new stations have been added to the service since the last report, and several enquiries have been received from other counties. Observers are still wanted for Adams, Cambria, Carbon, Greene, Jefferson, Juniata, Lehigh, Mifflin, Snyder, Union and Wyoming. No doubt there are persons in each of these counties, keeping daily records, who would gladly take part in an organized service if the subject were brought to their attention.

Attention is called to the paragraph in the January bulletin that relates to Weather Signals.

The promptness of those observers who send in their reports immediately after the close of the month is appreciated. As the value of the weekly Crop Reports made by Observers depends almost entirely on the cancelling of such words in *italics* on the form as do not apply to the conditions of the six preceding days for which the report is made, all Observers forwarding these forms are particularly requested to cancel all *italicized* words that do not apply to the conditions of the week for which the report is made, and to mail them so that they will reach this city by 4 P. M. on Saturday of each week.

The Committee on Meteorology of the FRANKLIN INSTITUTE,
W. P. TATHAM, *Chairman.*

REVIEW FOR FEBRUARY, 1888.

TEMPERATURE.

The mean temperature for February, for the State, was 28°.4, which is about 1° below the normal.

Fayette, Allegheny and Philadelphia report the highest monthly means, and Wayne, Sullivan, Warren and Erie the lowest.

The warmest period of the month prevailed on the 14th and 20th. Uniontown reports 63°; Pittsburgh, 61°; Indiana, 61°, and Greensburg, 60°. The cold wave of the 10th was general throughout the State, and the following low temperatures were reported: Dyberry, —31°; Columbus, —25°; Blooming Grove, —22°; Tionesta, —19°; Bernice, —19°; Wysox, —18°.5; Phillipsburg, —18°; Scranton, —17°; Eagles Mere, —16°, and Clarion, —16°. In some localities the lowest temperatures noted occurred on the 16th.

ATMOSPHERIC PRESSURE.

The mean barometer, 30.12, is slightly below the normal. The highest occurred on the 15th, and was accompanied by a cold wave. The lowest pressure was on the 25th, and was attended by heavy rains. Heavy snow and rain occurred during the depression of the 8th, and heavy rain with that of the 4th.

PRECIPITATION.

The average precipitation, including rain and melted snow, was 2.50 inches, which is from a half to one inch below the normal. The total precipitation in Eastern Pennsylvania was nearly double that in the western portion. Wellsboro reports 4.54 inches; West Chester, 4.97 inches; Quakertown, 4.26 inches, and Bernice, 4.46 inches, while Phillipsburg had but 0.89 inches, and Washington, 0.91 inches.

SNOWFALL.

The average snow was about 7 inches, and most of it fell during the first half of the month. The greatest totals reported were 18 inches at Bernice, 14.7 inches at Dyberry, and 14 inches at Eagles Mere. Very little snow was left on the ground at the end of the month.

WIND AND WEATHER.

High winds, causing damage, occurred at Bernice, 20th; Uniontown, 24th; Clarion, 24th; Catawissa, 25th; Scranton, 25th; Somerset, 25; Greensburg, 25th; Lebanon, 25th.

Prevailing wind direction for the month, Northwest.

Average number of clear days, 7; fair days, 11; cloudy days, 11; rainy days, 9.

MISCELLANEOUS PHENOMENA.

Auroras.—Bernice, 8th; Eagles Mere, 8th.

Solar Halos.—Charlesville, 1st, 14th, 19th; Eagles Mere, 11th, 14th, 17th, 19th, 21st, 28th; Wellsboro, 17th, 28th.

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Ser

County.	Station.	Elevation above Sea Level (feet).	Barometer.			Temperature.												Relative Humidity.	Dew Point.	Total Inches
							Maximum.		Minimum.				Daily Range.							
			Mean.	Highest.	Lowest.	Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.	Least.	Date.			
Allegheny,	Pittsburgh,	847	30·056	30·810	29·410	34·1	61·0	19	1·1	10	43·5	25·9	17·6	33·6	16	6·6	1	71·0	25·3	1·7
Armstrong,	Kittanning,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Beaver,	Rochester,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Bedford,	Charlesville,	1,500	...	...	...	29·1	58·5	14	0·5	10	39·9	20·0	19·9	39·5	13	5·0	4	75·4	21·8	1·9
Berks,	Reading— Selwyn Hall School,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Berks,	Kutztown— Keystone State Normal School,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Blair,	Altoona,*	1,209	...	...	...	34·7	59·0	15	—2·0	10	...	...	...	...	...	...	...	72·4	27·0	1·3
Blair,	Hollidaysburg,	947	...	...	...	29·5	58·0	14	—9·0	10	41·0	17·9	23·1	43·0	14	8·0	12	70·5	20·6	2·1
Bradford,	Wysox,	718	...	...	...	27·0	50·5	20	—18·5	10	36·2	17·0	19·2	42·0	15	9·5	27	73·9	19·8	1·2
Bucks,	Quakertown,	536	30·130	30·680	29·560	27·3	50·0	20	—4·0	16	37·4	17·2	20·2	42·0	15	10·0	25	83·6	22·0	4·2
Butler,	Butler,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cameron,	Emporium,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Centre,	State College— Agricultural Experiment Station,	1,191	30·161	30·792	29·575	28·5	56·0	14	—13·0	10	36·1	16·6	19·5	40·5	15	7·5	5	84·9	23·4	1·7
Centre,	Phillipsburg,	1,350	...	...	...	28·1	55·0	14	—18·0	12	39·6	16·5	23·1	...	...	...	...	...	...	0·6
Chester,	West Chester,	455	30·210	30·639	29·518	30·7	53·5	20	—1·0	16	38·4	22·6	15·8	34·0	15	5·0	12	72·0	22·0	4·3
Chester,	Coatesville,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Clarion,	Clarion— State Normal School,	1,330	...	...	...	26·7	51·0	20	—16·0	10	36·0	16·7	19·3	36·0	10	9·0	1	83·0	21·8	1·7
Clearfield,	Grampian Hills,	1,450	...	...	...	25·5	54·0	20	—14·0	10	34·2	17·6	16·6	34·0	16	4·0	4, 5	...	...	1·7
Clinton,	Lock Haven,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Columbia,	Catawissa,	491	...	...	...	30·3	53·0	20	—9·0	10	38·9	19·5	18·5	46·0	17	6·0	26, 27	71·5	21·5	2·0
Crawford,	Meadville— Allegheny College,	1,252	30·120	30·866	29·345	31·5	52·0	14	—8·0	10	38·6	19·4	19·2	35·0	8	3·0	2	74·7	24·2	1·5
Cumberland,	Carlisle— Dickinson College,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cumberland,	Carlisle,	480	...	...	...	27·4	50·3	22	0·0	16	...	...	...	...	...	...	...	78·8	21·4	3·2
Dauphin,	Harrisburg,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Delaware,	Swarthmore— Swarthmore College,	190	30·093	30·469	29·593	31·2	55·2	20	1·9	16	39·4	24·1	15·3	35·5	15	3·1	12	77·0	24·1	2·7
Elk,	Ridgway,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Erie,	Erie,	681	30·070	30·820	29·370	26·0	51·0	20	—8·0	10	37·8	18·1	19·7	37·0	16	6·5	18	77·0	19·0	1·9
Fayette,	Uniontown,	1 000	30·057	30·591	29·492	35·2	63·0	19	5·0	10	44·6	26·7	17·9	35·0	19	4·0	26	85·0	31·0	1·2
Forest,	Tionesta,	1,058	...	...	...	25·8	53·0	20	—19·0	10	37·6	15·2	22·4	40·0	10	9·0	4, 26	71·0	18·0	...
Franklin,	Chambersburg— Wilson Female College,	618	30·138	30·531	29·632	26·1	51·0	22	0·0	10	38·2	17·4	20·8	39·0	17	9·0	7, 12	85·7	21·1	3·9
Fulton,	McConnellsburg,	875	...	...	...	30·9	58·0	14	3·0	10	41·7	22·5	20·2	43·0	14	4·0	4	76·9	23·8	2·2
Huntingdon, ‡	Huntingdon— The Normal College,	650	...	...	...	28·5	58·0	14	—12·0	10	41·3	17·0	24·3	46·0	14	9·5	4	76·6	20·2	1·8
Indiana,	Indiana— State Normal School,	1,390	...	...	...	29·6	61·0	20	—4·5	10	38·4	19·4	19·0	37·0	16	7·5	26	86·3	24·2	1·6
Lackawanna,	Scranton,	750	...	...	...	26·7	51·0	20	—17·0	10	38·0	15·8	22·2	44·0	15	13·0	5	85·8	21·2	3·1
Lancaster,	Lancaster— Franklin and Marshall College,	413	30·143	30·682	29·560	28·7	50·7	20	—2·3	16	38·5	20·0	18·5	37·4	17	5·6	7	80·0	21·3	2·1
Lawrence,	New Castle,	932	...	...	...	30·1	53·0	23	—6·0	10	38·4	19·3	19·1	34·0	15, 16	6·0	1, 2	80·3	24·2	1·8
Lebanon,	Lebanon,	480	...	...	...	27·8	48·3	20	—1·5	9	37·5	18·9	18·6	41·3	17	6·1	7, 12	80·7	22·3	3·8
Luzerne,	Drifton— Drifton Hospital,	1,653	...	...	...	25·7	52·0	14	—12·0	16	37·9	13·6	22·3	51·0	13	13·0	18	...	...	2·1
Lycoming,	Williamsport,†	...	...	...	...	29·9	43·0	20	—4·0	16	35·8	19·9	15·9	33·0	17	5·0	27	76·4	22·4	1·1
McKean,	Smethport,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mercer,	Greenville— Thiel College,	1,000	30·012	30 778	29·511	26·5	51·5	20	—11·2	10	36 8	16·3	20·3	35·5	8	5·5	7	81·8	20·7	1·7
Monroe,	Stroudsburg,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Montgomery,	Pottstown,	150	...	...	...	26·3	54·0	20	0·0	16	37·5	22·3	15·2	35·0	14, 17	1·0	4	76·1	20·1	4·0
Northampton,	Bethlehem,	300	...	...	...	28·8	55·0	21	—4·0	10	36·9	17·4	19·5	42·0	17	8·0	12	73·0	21·0	3·1
Northumberland,	Shamokin,	733	...	...	...	28·0	55·0	14	—10·0	10	39·1	18·2	20·9	51·0	15	11·0	7	83·7	23·2	2·1
Perry,	New Bloomfield,	400	...	...	...	26·7	54·0	14	—7·5	10	35·9	14·7	20·2	45·0	14	4·0	4	...	...	2·1
Philadelphia,	Philadelphia,	117	30·116	30·680	29·490	34·1	58·5	20	2·5	16	41·7	26·1	15·6	31·5	15	6·6	12	70·0	24·5	2·1
Pike,	Blooming Grove,	800	...	...	...	25·6	52·0	14	—22·0	10	...	...	...	...	...	...	...	...	...	2·1
Potter,	Coudersport,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Schuylkill,	Girardville,	1,030	30·120	30·710	29·480	28·0	50·0	14	—4·0	10	35·3	18·4	16·9	32·0	11	1·0	1	...	...	3·1
Somerset,	Somerset,	2,250	...	...	...	29·6	57·5	20	—6·0	10	35·6	19·9	15·7	35·5	16	4·0	28	81·8	25·0	1·1
Sullivan,	Eagles Mere,	2,060	...	...	...	22·2	49·0	14	—16·0	10	32·5	14·2	18·3	47·0	15	6·0	9	73·4	15·0	3·1
Sullivan,	Bernice,	2,200	...	...	...	23·3	49·0	14, 24	—19·0	10	33·1	13·6	13·5	44·0	15	10·5	1	80·2	17·5	4·1
Susquehanna,	Montrose,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Tioga,	Wellsboro,	1,327	30·081	30·742	29·549	26·3	55·0	14	—17·0	10	35·5	19·7	15·8	42·1	14	1·2	15	87·1	28·2	4·1
Venango,	Franklin,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Washington,	Scenery Hill,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Washington,	Washington,	1,175	...	...	...	32·5	59·0	20	2·5	10	38·9	24·4	14·5	31·0	19	2·2	1	...	...	0·7
Warren,	Columbus,	1,410	...	...	...	24·9	55·0	12	—23·0	10	35·3	14·3	21·0	59·0	12	0·0	5	...	...	2·7
Wayne,	Dyberry,	1,100	...	...	...	20·9	47·0	14	—31·0	10	32·6	8·1	24·5	44·0	15	4·0	4	...	...	3·1
Westmoreland,	Greensburg,	1,075	...	...	...	32·5	60·0	22	—2·0	10	42·4	23·5	18·9	34·5	10	5·0	11	80·0	27·1	1·1
York,	York,	385	...	...	...	29·7	53·5	20	5·6	10	38·6	21·6	17·0	39·0	14	5·0	4	75·6	22·6	2·1

* Observations taken at 12, Noon. † From 15th. ‡ Huntingdon's lowest temperature for January should read —7·5.

Voluntary Observers of the Pennsylvania State Weather Service for Febru

Temperature.									Relative Humidity.	Dew Point.	Precipitation.		
Minimum.		Mean of Maximum.	Mean of Minimum.	Daily Range.									
Lowest.	Date.			Mean.	Greatest.	Date.	Least.	Date.			Total Inches.	Total Depth of Snow (inches).	Number of Days Rainfall.
1·1	10	43·5	25·9	17·6	33·6	16	6·6	1	71·0	25·3	1·74	—	12
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
0·5	10	39·9	20·0	19·9	39·3	13	5·0	4	75·4	21·8	1·92	8·5	9
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
—2·0	10	. . .	. . .	. . .	. . .	. . .	. . .	. . .	78·4	27·0	1·17	. . .	9
—0·0	10	41·0	17·9	23·1	43·0	14	8·0	12	70·5	20·6	2·12	9·0	6
—18·5	10	36·2	17·0	19·2	42·0	15	9·5	27	73·9	19·8	1·25	7·1	8
—4·0	16	37·4	17·2	20·2	42·0	15	10·0	25	83·6	22·0	4·26	. . .	13
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
—13·0	10	36·1	16·6	19·5	40·5	13	7·5	5	84·9	23·4	1·78	4·7	10
—18·0	12	39·6	16·5	23·1	. . .	. . .	. . .	. . .	. . .	. . .	0·89	6·0	. . .
—1·0	16	38·4	22·6	15·8	34·0	13	5·0	12	72·0	22·0	4·97	4·0	15
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
—16·0	10	36·0	16·7	19·3	36·0	10	9·0	1	83·0	21·8	1·79	. . .	6
—14·0	10	34·2	17·6	16·6	34·0	16	4·0	4, 5	. . .	. . .	1·73	3·0	8
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
—9·0	10	38·0	19·3	18·5	46·0	17	6·0	26, 27	71·5	21·5	2·03	9·2	9
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
—8·0	10	38·6	19·4	19·2	35·0	8	3·0	2	74·7	24·2	1·55	16·3	7
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
0·0	16	. . .	. . .	. . .	. . .	. . .	. . .	. . .	78·8	21·4	3·37	7·6	13
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
1·9	16	39·4	24·1	15·3	35·5	13	3·1	12	77·0	24·1	2·74	3·5	6
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
—8·0	10	37·8	18·1	19·7	37·0	16	6·5	18	77·0	19·0	1·66	. . .	9
3·0	10	44·6	26·7	17·9	35·0	19	4·0	26	85·0	31·0	1·26	1·3	5
—19·0	10	37·6	15·2	22·4	40·0	10	9·0	4, 26	71·0	18·0	. . .	. . .	. . .
0·0	10	38·2	17·4	20·8	39·0	17	9·0	7, 12	85·7	21·1	3·91	4·5	8
3·0	10	41·7	21·5	20·2	43·0	24	4·0	4	76·9	23·8	2·76	. . .	10
—11·0	10	41·3	17·0	24·3	46·0	14	9·5	4	76·6	20·2	1·83	5·7	9
—4·5	10	38·4	19·4	19·0	37·0	16	7·5	26	86·3	24·2	1·84	. . .	10
—17·0	10	38·0	15·8	22·2	44·0	15	13·0	5	85·8	21·2	3·05	11·3	8
—2·3	16	38·5	20·0	18·5	37·4	17	5·6	7	80·0	23·3	2·52	8·0	8
—6·0	10	38·4	19·3	19·1	34·0	15, 16	6·0	1, 2	80·3	24·2	1·83	2·6	7
—1·5	9	37·5	18·9	18·6	41·3	17	6·1	7, 12	80·7	22·3	3·89	8·7	13
—11·0	16	37·9	15·6	22·3	51·0	15	13·0	18	. . .	. . .	2·63	. . .	5
—4·0	16	35·8	19·9	15·9	33·0	17	5·0	27	76·4	22·4	1·30	. . .	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
—11·2	10	36·8	16·5	20·3	35·5	8	5·3	7	81·8	20·7	1·63	3·0	12
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
0·0	16	37·5	22·3	15·2	35·0	14, 17	2·0	4	76·1	20·1	4·08	5·5	9
—4·0	10	36·9	17·4	19·5	42·0	17	8·0	12	73·0	21·0	3·50	. . .	7
—10·0	10	39·1	18·2	20·9	51·0	15	11·0	7	83·7	23·2	2·01	6·2	10
—7·5	10	35·9	14·7	20·2	45·0	14	4·0	4	. . .	. . .	2·92	8·2	8
2·5	16	41·7	26·1	15·6	31·5	15	6·6	12	70·0	24·5	2·57	2·1	13
—22·0	10	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2·47	12·0	6
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
—4·0	10	35·3	18·4	16·9	32·0	11	1·0	1	. . .	. . .	3·45	11·7	9
—6·0	10	35·0	19·9	14·7	35·5	16	4·0	28	81·8	25·0	1·34	3·8	8
—16·0	10	32·5	14·2	18·3	47·0	15	6·0	9	73·4	15·0	3·87	14·0	7
—19·0	10	33·1	13·6	13·5	44·0	15	10·5	1	80·2	17·5	4·46	18·0	13
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
—17·0	10	35·5	19·7	15·8	42·1	14	1·2	15	87·1	28·2	4·54	5·0	6
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
2·5	10	38·9	24·4	14·5	31·0	19	9·8	1	. . .	. . .	0·01	. . .	8
—25·0	10	35·3	14·3	21·0	59·0	12	0·0	5	. . .	. . .	2·03	. . .	11
—31·0	10	32·6	8·1	24·5	41·0	15	4·0	4	. . .	. . .	3·07	14·7	13
—2·0	10	42·4	23·5	18·9	34·5	10	5·0	11	80·2	27·1	1·28	3·7	8
5·6	10	38·6	21·6	17·0	39·0	14	5·0	4	75·6	22·6	2·20	7·8	11

hould read —7·5.

PRECIPITATION.		NUMBER OF DAYS.			WIND.	OBSERVERS.
Total Depth of Snow (inches).	Number of Days Rainfall.	Clear.	Fair.	Cloudy.	Prevailing Direction.	
—	12	5	15	9	NW	Oscar D Stewart, Sgt. Sig. Corps.
. .	. . .	. . .	. . .	. . .	. . .	Tyson Heilman.
. .	. . .	. . .	. . .	. . .	. . .	Hon Hartford P. Brown.
8·5	9	8	13	10	NW	Rev. A. Thos. G. Apple.
. .	. . .	. . .	. . .	. . .	. . .	Prof. George A. Ruddle.
. .	. . .	. . .	. . .	. . .	. . .	Prof. J. H. Rohrbach.
. .	9	. . .	. . .	. . .	. . .	Dr. Charles B. Dudley.
2·0	6	14	5	10	W	Prof. J. A. Stewart.
7·1	8	5	10	14	NW	Charles Beecher.
. .	13	6	18	8	NE	J. L. Heacock.
. .	. . .	. . .	. . .	. . .	. . .	J. E. Forsythe.
. .	. . .	. . .	. . .	. . .	. . .	T. B. Lloyd.
4·7	10	6	11	12	W	Prof. Wm. Frear.
6·0	. . .	. . .	. . .	. . .	SW	L. Ray Morgan.
4·0	15	12	9	8	NW	Jesse C. Green, D.D.S.
. .	. . .	. . .	. . .	. . .	. . .	W. T. Gordon.
. .	6	4	15	10	SW	J. H. Apple, A.B.
3·0	8	11	10	8	W	Nathan Moore.
. .	. . .	. . .	. . .	. . .	. . .	Prof. John A. Robb.
9·2	9	12	7	10	NW	Robert M. Graham.
16·5	7	. . .	. . .	. . .	. . .	Prof. J. H. Montgomery.
. .	. . .	. . .	. . .	. . .	. . .	Prof. Charles F. Himes, Ph.D.
7·6	13	9	11	9	W	J. E. Pague.
. .	. . .	. . .	. . .	. . .	. . .	Zenos J. Gray, M.D.
3·3	6	10	10	9	NW	Prof Susan J. Cunningham.
. .	. . .	. . .	. . .	. . .	. . .	Joe Messinger.
. .	9	6	12	11	S, NW	Peter Wood, Sgt Sig. Corps.
1·5	5	12	8	9	NW, SW	Wm. Hunt.
. .	. . .	10	10	9	SW	Robert L. Haslet.
4·5	8	12	9	8	. . .	Miss Mary A. Ricker.
. .	10	11	11	7	W	Thomas F. Sloan.
5·7	9	7	13	9	W	Prof. W. J. Swigart.
. .	10	7	11	11	W, SW	Prof. Albert E Maltby.
11·3	8	9	9	11	NW	T. F. Heebner, M.D.
8·0	8	5	10	14	W	A. M. Schmidt, A.B.
2·6	7	3	17	9	NW	Wm. T. Butz.
8·7	13	9	10	10	NW, NE	George W. Hayes, C.E., Ph.G.
. .	5	. . .	. . .	. . .	NW	H. D. Miller, M.D.
. .	. . .	. . .	. . .	. . .	NW	E. H. Baker.
. .	. . .	. . .	. . .	. . .	. . .	Armstrong & Brownell.
3·0	12	3	9	15	NW	Prof S. H. Miller.
. .	. .	. . .	. . .	. . .	. . .	N. C. Miller, M.D.
5·5	9	10	11	8	NW	Charles Moore, D.D.S.
. .	7	. . .	. . .	. . .	W	Lerch & Rice.
6·2	10	7	13	9	W	G. R. Hanley.
8·2	8	14	5	10	W	Frank Mortimer.
2·1	13	6	16	7	NW	Luther M. Dey, Sgt. Sig. Corps.
12·0	6	. . .	. . .	. . .	W	John Grathwohl.
. .	. . .	. . .	. . .	. . .	. . .	D. W. Butterworth.
11·7	9	11	9	9	NW	E. C Wagner.
3·8	8	7	8	14	NW, SW	W. M. Schrock.
14·0	7	4	11	14	SW	E. S. Chase.
18·0	13	5	12	12	W	C R. Claghorn.
. .	. .	. . .	. . .	. .	. .	A. H. Berlin.
5·0	6	9	11	16	N	H. D. Deming.
. .	. .	. . .	. . .	. . .	. . .	Prof. N. P. Kinsley.
. .	. .	. . .	. . .	. . .	. . .	Jacob Gayman.
. .	8	9	14	13	NW, SW	Harrison Otis.
. .	11	3	14	12	SW	Wm. Loveland.
14·7	13	3	12	14	NW	Theodore Day.
3·7	8	2	17	10	SW	H. S. Brunot.
7·8	11	9	10	10	NW	Mrs. L. H. Grenewald.

T. F. TOWNSEND, *Sergeant Signal Corps, Assistant.*

PRECIPITATION FOR FEBRUARY, 1888.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Erie.	.	.	.06	.06	.01	.03	.	.	.	.	.	.	.	.48	.	.	.	.	.	.05	.08	.	.	.	.	.	.06	.	.	.	.	1.46
Meadville.	.	.	.06	.06	.10	.10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.10	.	.	.	.	1.55
Greenville.	.	.	.04	.01	.01	.18	.	.	.	.	.	.	.	.06	.	.	.	.	.	.04	.01	.	.	.	.	.	.41	.01	.	.	.	1.63
New Castle.	.	.	.03	.	.	.15	.	.	.	.	.	.	.	.03	.	.	.	.	.	.07	.	.	.	.	.	.	.08	.03	.08	.	.	1.83
Washington.	.	.	.07	.06	.	.08	.	.	.	.	.	.	.	.01	.	.	.	.	.	.16	.	.	.	.	.	.	.06	.02	.01	.	.	0.91
Pittsburgh.	.	.	.03	.05	.01	.01	.	.	.	.	.	.	.	.01	.	.	.	.	.	.10	.	.	.	.	.	.	.11	.00	.05	.	.	1.24
Columbus.	.	.	.45	.37	.00	.03	.	.	.	.	.	.	.	.14	.	.	.	.	.	.20	.	.	.	.	.	.	.05	.05	.02	.	.	2.03
Clarion.	.	.	.70	.30	.15	.03	.	.	.	.	.	.	.	.03	.	.	.	.	.	.18	.	.	.	.	.	.	.43	.01	.08	.	.	1.79
Greensburg.	.	.	.63	.19	.03	.03	.	.	.	.	.03	.	.	.06	.	.	.	.	.	.06	.	.	.	.	.	.	.38	.01	.08	.	.	1.98
Uniontown.	.	.	.96	.13	.08	.08	.	.	.	.	.06	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.23	.	.	.	.	1.26
Indiana.	.	.	.48	.18	.01	.13	.	.	.	.	.01	.	.	.60	.	.	.	.	.	.01	.	.	.	.	.	.	.46	.02	.04	.	.	1.84
Somerset.	.	.	.60	.08	.01	.01	.	.	.	.	.03	.	.	.	.	.	.	.	.	.09	.	.	.	.	.	.	.41	.00	.	.	.	1.31
Grampian Hills.	.	.	.73	.11	.13	.04	.	.	.	.	.04	.	.	.	.	.	.	.	.	.21	.	.	.	.	.	.	.45	.03	.01	.	.	1.73
Phillipsburg.	.	.	.53	.	.01	.03	.	.	.	.	.03	.	.	.	.	.	.	.	.	.11	.	.	.	.	.	.	.01	.01	.01	.	.	0.80
Hollidaysburg.	.	.	.41	.	.21	.	.	.	.	.	.48	.	.	.28	.	.	.	.	.	.18	.	.	.	.	.	.	.68	.	.	.	.	2.12
Altoona.	.	.	.32	.04	.10	.14	.	.	.	.	.14	.	.	.08	.	.	.	.	.	.12	.	.	.	.	.	.	.34	.03	.	.	.	1.11
Charlesville.	.	.	.38	.03	.17	.04	.	.	.	.	.04	.	.	.	.	.	.	.	.	.15	.	.	.	.	.	.	.66	.	.	.	.	1.92
State College.	.01	.	.28	.05	.19	.05	.	.	.	.	.14	.	.	.08	.	.	.	.	.	.46	.	.	.	.	.	.	.48	.01	.	.	.	1.72
Huntingdon.	.	.	.19	.05	.22	.11	.	.	.	.	.47	.	.	.08	.	.	.	.	.	.21	.	.	.	.	.	.	.68	.02	.	.	.	1.83
McConnellsburg.	.	.	.66	.05	.16	.15	.	.	.	.	.45	.15	.	.03	.	.	.	.	.	.96	.	.	.	.	.	.	.67	.00	.	.	.	2.76
Chambersburg.	.	.	.85	.05	.05	.05	.	.	.	.	.13	.20	.	.75	.	.	.	.	.	.90	.	.	.	.	.	.	1.00	.00	.	.	.	3.95
New Bloomfield.	.	.	.80	.35	.15	.06	.	.	.	.	.28	.15	.	.06	.	.	.	.	.	.60	.	.	.	.	.	.	1.30	.00	.	.	.	3.98
Carlisle.	.	.	.66	.01	.17	.05	.	.	.	.	.14	.03	.	.05	.	.	.	.	.	.03	.	.	.	.	.	.	.15	.06	.	.	.	3.17
York.	.	.	.64	.06	.08	.05	.	.	.	.	.14	.07	.	.01	.	.	.	.	.	.89	.	.	.	.	.	.	.48	.12	.	.	.	3.00
Wysox.	.	.	.11	.08	.13	.44	.	.	.	.	.	.	.	.	.	.	.	.	.	.03	.09	.	.	.	.	.	.18	.10	.	.	.	1.65
Eagles Mere.	.	.	.53	.45	.43	.04	.	.	.	.	.09	.13	.	.04	.	.	.	.	.	1.13	1.01	.18	.	.	.	.	1.01	.18	.	.	.	3.87
Bernice.	.	.	.48	.30	.14	.47	.13	.07	.	.	.13	.08	.	.07	.	.	.	.	.	1.35	.03	.	.	.	.	.	.18	.05	.03	.	.	4.46
Catawissa.	.	.	.36	.07	.30	.13	.19	.05	.	.	.30	.13	.	.05	.	.	.	.	.	.47	.	.	.	.	.	.	.26	.05	.03	.	.	2.03
Shamokin.	.	.	.54	.39	.15	.22	.05	.07	.	.	.07	.05	.	.01	.	.	.	.	.	.79	.	.	.	.	.	.	.46	.	.	.	.	2.61
Girardville.	.	.	.57	.08	.18	.24	.08	.36	.	.	.08	.08	.	.36	.	.	.	.	.	1.11	.	.	.	.	.	.	.72	.	.	.	.	3.45
Lebanon.	.08	.17	.03	.23	.17	.07	.96	.13	.	.	.96	.07	.	.01	.	.	.	.	.	.82	.	.	.	.	.	.	.77	.25	.01	.	.	3.89
Lancaster.	.40	.09	.13	.09	.25	.05	.26	.	.	.	.07	.05	.	.26	.	.	.	.	.	.60	.	.	.	.	.	.	.23	.	.	.	.	2.58
Drifton.	.64	.04	.96	.	.	.	.	.	.	.	.41	.	.	.	.	.	.	.	.	.98	.	.	.	.	.	.	.	.	.	.	.	2.63
Scranton.	.55	.05	.48	.20	.	.	.	.	.	.	.48	.02	.	.	.	.	.	.	.	.86	.	.	.	.	.	.	.67	.	.	.	.	3.35
Pottstown.	.70	.	.24	.80	.24	.28	.45	.13	.	.	.45	.	.	.55	.	.	.	.	.	.55	.	.	.	.	.	.	1.40	.30	.	.	.	4.08
West Chester.	.67	.09	.21	.40	.21	.16	.19	.05	.	.	.16	.05	.	.55	.03	.	.04	.	.	.55	.	.	.	.	.	.	1.02	.10	.03	.	.	4.07
Dyberry.	.47	.17	.06	.29	.10	.32	.01	.03	.	.	.32	.03	.	.10	.	.	.03	.	.	.10	.	.	.	.	.	.	.48	.06	.	.	.	3.07
Blooming Grove.	.40	.09	.38	.	.	.90	.	.	.	.	.90	.	.	.	.	.	.	.	.	.90	.	.	.	.	.	.	.40	.	.	.	.	3.47
Bethlehem.	.73	.38	.12	.60	.	.	.	.	.	.	.12	.	.	.80	.	.	.	.	.	.80	.	.	.	.	.	.	.81	.	.	.	.	3.50
Quakertown.	.60	.13	.05	.39	.14	.37	.15	.05	.	.	.37	.05	.	.85	.	.	.	.	.	.85	.	.	.	.	.	.	.89	.18	.	.	.	4.06
Swarthmore.	.30	.05	.06	.36	.	.	.	.	.	.	.58	.	.	.	.	.	.	.	.	.58	.	.	.	.	.	.	1.09	.33	.	.	.	3.74

T. F. T

Lunar Halos.—Catawissa, 3d, 21st; Dyberry, 17th; Bernice, 21st; McConnellsburg, 17th; Carlisle, 17th, 19th; Indiana, 20th; Charlesville, 17th, 22d; West Chester, 19th; Somerset, 17th; Chambersburg, 17th; Lebanon, 19th, 21st; Greenville, 17th; New Castle, 21st; Washington, 17th, 23d; Clarion, 21st; Eagles Mere, 19th, 20th.

Lunar Coronæ.—Dyberry, 1st; Huntingdon, 21st; Charlesville, 28th; York, 22d; Girardville, 26th; Tionesta, 21st; Greensburg, 17th; Lebanon, 17th, 19th, 21st, 23d, 28th; Indiana, 27th.

Polar Bands.—Catawissa, 12th.

Zodiacal Lights.—Dyberry, 2d, 3d, 6th.

Thunder Storm.—Greensburg, 20th.

MIGRATION OF BIRDS.

Blue Birds.—Charlesville, 19th; Quakertown, 22d; Greenville, 22d; Dyberry, 24th.

Robins.—Dyberry, 19th; Greenville, 22d; Quakertown, 26th.

Black Birds.—Quakertown, 26th.

CROPS.

Winter wheat has been well protected by snow, and is reported in good condition. T. F. T.

WEATHER SIGNALS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
Chester Oil Company,	Chester.
C. W. Burkhart,	Shoemakerville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Werner & Son,	Emporium.
C. E. Lenhart,	Latrobe.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
S. W. Morrison,	Oxford.
Capt. A. Goldsmith,	Quakertown.
J. L. Morrison,	Sharon.
Wm A. Engel,	Shenandoah.
Wm. Schrock,	Somerset.
Postmaster,	Meadville.

Displayman.	*Station.*
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
E. H. Baker,	Williamsport.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
E. S. Chase,	Eagles Mere.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
Armstrong & Brownell,	Smethport.
J. E. Forsythe,	Butler.
James H. Fones,	Tionesta.
Wister, Hacker & Savage,	Germantown.
W. J. Thompson & Co.,	Clifton Heights.
Steward M. Dreher,	Stroudsburg.
State Normal School,	Millersville.
E. C. Wagner,	Girardville.

PENNSYLVANIA STATE WEATHER SERVICE BULLETIN

FOR MARCH, 1888.

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, March 31, 1888.

Observers are requested to note and report the effect of late frosts on fruits and small crops, also to be prompt in sending in their Weekly Crop Reports, which should always be mailed on Friday. On these should be entered the time of seeding, harvesting, etc. The practice of attaching to these reports brief newspaper clippings relative to crops is commendable. Particular attention should be paid to the measurement of rainfall and the recording of the time of beginning and ending. Instructions to observers should be closely studied and followed, to give the highest value to their reports.

Correspondence is requested with a view of establishing stations in the counties from which no reports are received.

The Committee on Meteorology of the FRANKLIN INSTITUTE,

W. P. TATHAM, *Chairman.*

REVIEW FOR MARCH, 1888.

TEMPERATURE.

The mean temperature for Pennsylvania for the month was 31°·1, which is from 2° to 5° below the March average. The greatest departures occurred in the eastern portions of the State. The extreme low temperatures were not absolutely lower than usual, but they were of longer duration. The unusual cold, the numerous cloudy and stormy days, the severe storm of the 11th and 12th, have all combined to make the past month exceptionally disagreeable and memorable. The minimum temperatures occurred on the 6th and 13th. The lowest are: Eagles Mere, —6°·0; Bernice, —5°·5; Drifton, —5°·0; Dyberry, —5°·0, and Montrose, —4°·0. The maxima were during the latter part of the month, most of which were noted on the 20th, 21st, 30th and 31st. The highest are Uniontown, 72°·0; Pittsburgh, 71°·5; Philadelphia, 70°·0; York, 69°·0, and New Castle, 69°·0.

ATMOSPHERIC PRESSURE.

The mean barometer of 30·02 is about ·07 below the average. The high pressures were on the 9th and 25th, and the lowest on the 21st. The latter was attended by heavy rains throughout the State.

PRECIPITATION.

The average precipitation, including rain and melted snow, was 3·55 inches.

This amount was very unevenly distributed, much the larger portion falling over the eastern section of the State, causing an excess, and leaving a deficiency in the western counties. The greatest precipitation occurred on the 11th, 12th, 21st and 26th. The largest totals for the month are West Chester, 6·39 inches; Coatesville, 6·28 inches; Philadelphia, 5·42 inches; Swarthmore, 5·34 inches, and Pottstown, 5·35 inches.

SNOWFALL.

The snowfall was variable in quantity, and ranged from a depth of 20 inches at Eagles Mere, 19 inches at Bernice, Coatesville, Girardville and Dyberry, to 2 and 3 inches at the western stations.

The greater portion of the snow fell on the 11th and 12th, and for these days Eagles Mere reports 13 inches; Dyberry, 14 inches; Girardville, 12 inches; Quakertown, 12 inches; West Chester, 10 inches; Coatesville, 10 inches; Philadelphia, 10 inches; Stroudsburg, 8 inches; Pottstown, 7 inches, and Scranton, 7 inches.

WIND AND WEATHER.

The severe storm of the 11th and 12th was most remarkable and destructive, and the people of Pennsylvania experienced very many of the inconveniences and disastrous effects of a genuine blizzard. On the night of the

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather

County.	Station.	Elevation above Sea Level (feet).	Barometer.			Temperature.													Relative Humidity.	Dew Point.
							Maximum.		Minimum.				Daily Range.							
			Mean.	Highest.	Lowest.	Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.	Least.	Date.		
Allegheny,	Pittsburgh,	847	30·082	30·480	29·160	36·3	71·5	20	9·1	13	46·3	27·5	18·8	36·0	19	8·4	13	71·2	27·3
Armstrong,	Kittanning,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Beaver,	Rochester,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Bedford,	Charlesville,	1,500	...	...	...	31·8	67·0	20, 30	1·0	6	41·5	23·0	18·5	35·0	18	3·0	25	72·0	24·0
Berks,	Reading— Selwyn Hall School,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Berks,	Kutztown— Keystone State Normal School,	1,500	...	...	...	29·9	59·6	21	2·0	13	38·4	23·9	14·5	28·0	4	3·5	2	...	...
Blair,	Altoona,*	1,209	30·252	30·699	29·742	35·7	65·5	31	4·0	13	46·1	25·6	20·5	39·0	12	10·5	8	73·3	28·0
Blair,	Hollidaysburg,	947	...	...	...	31·8	78·0	30	2·0	7	42·1	20·3	21·8	36·0	18	6·0	13	69·6	...
Bradford,	Wysox,	718	...	...	...	30·6	65·0	21	2·0	13	40·4	21·9	18·5	43·2	19	3·0	7	74·1	23·0
Bucks,	Quakertown,	536	30·090	30·540	29·410	30·6	65·0	31	2·0	13	40·6	21·5	19·1	32·0	19	9·0	26	80·5	24·7
Butler,	Butler,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cameron,	Emporium,	1,030	...	...	...	31·4	61·0	30	1·0	24	41·6	22·9	18·7	40·0	19	9·0	2	69·2	22·4
Centre,	State College— Agricultural Experiment Station,	1,191	30·134	30·537	29·365	30 5	58·0	30, 31	—1·5	13	38·2	17·8	20·4	32·5	19	12·0	5, 12	81·4	24·0
Centre,	Phillipsburg,	1,350	...	...	...	30·1	66·0	31	0·0	13	43·2	22·1	21·1	41·0	9	2·0	20	...	...
Chester,	West Chester,	455	30·077	30·557	29·390	32·6	67·5	31	6 0	13	40·8	24·0	16·8	28·0	30	8·0	2	68·0	23·4
Chester,	Coatesville,	380	...	...	...	32·3	68·5	31	—3·0	6	41·4	23·2	18·2	41·5	31	3·5	...	...	...
Clarion,	Rimersburg,	1,500	...	...	...	30·1	66·0	19	0·0	13	36·7	23·0	13·7	26·0	19	4·0	13	...	...
Clarion,	Clarion— State Normal School,	1,530	...	...	...	25·7	66·0	19	1·0	13	36·2	16·4	19·8	40·0	19	6·0	13	83·0	21·0
Clearfield,	Grampian Hills,	1,450	30·927	30·273	29·175	28·1	62·0	20	0·0	13	35·7	20·4	15·3	34·0	18, 19	6·0	7	...	...
Clinton,	Lock Haven,	560	...	...	...	32·2	62·0	31	6·0	13	...	...	...	...	...	...	...	...	...
Columbia,	Catawissa,	491	...	...	...	35·0	66·5	21	3·0	14	41·9	25·0	16·9	35·5	18	5·5	2, 3, 22	68·0	25·0
Crawford,	Meadville— Allegheny College,	1,252	30·114	30·801	29·326	31·4	66·0	20	3·0	24	41·8	23·8	18·0	32·0	23	5·0	13	77·0	25·2
Cumberland,	Carlisle— Dickinson College,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cumberland,	Carlisle,	480	...	...	...	32·2	68·0	31	6·0	5	39·5	25·6	13·9	32·0	30	0·5	2	80·0	27·0
Dauphin,	Harrisburg,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Delaware,	Swarthmore— Swarthmore College,	190	30·072	30·543	29·620	33·1	69·5	31	6·0	6	41·9	25·3	16·6	28·5	31	8·6	17	72·0	25·2
Elk,	Ridgway,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Erie,	Erie,	681	30·110	30 560	29·140	27·0	67·4	19	3·0	24	36·5	20·2	16·3	38·9	19	5·5	5, 28	76·9	20·2
Fayette,	Uniontown,	1,000	30·033	30·386	29·499	37·4	72·0	20, 27	7·0	6	46·1	27·0	19·1	42·0	19	8·0	17	73·2	29·5
Forest,	Tionesta.	1,058	...	...	...	28·4	68·0	20	5·0	13, 24	43·2	21·1	22·1	42·0	19	10·0	16	75·2	21·4
Franklin,	Chambersburg— Wilson Female College,†	618	30·093	30·578	29·309	30·3	63·5	21	—5·0	6	40·1	23·1	17·0	38·0	19	7·0	5	81·5	24·7
Fulton,	McConnellsburg,	875	...	...	...	33·5	68 o	31	0·1	6	44·2	24·5	19·7	33·0	6	6·0	13	74·7	26·4
Huntingdon,	Huntingdon— The Normal College,	650	...	...	...	33·7	65·0	20	7·0	13, 14	42·9	23·8	19·1	36·0	19	10·0	2	75·9	26·7
Indiana,	Indiana— State Normal School,	1,350	...	...	...	32·7	67·8	20	3·0	13	40·8	23·2	17·6	36·0	19	6·0	13	86·5	28·8
Lackawanna,	Scranton,	750	...	...	...	29·4	63·0	21	0·0	13	40·4	19·4	21·0	37·0	19	10·0	13	82·6	24·2
Lancaster,	Lancaster— Franklin and Marshall College,	413	...	...	...	32·4	63·7	21	1·5	6	41·5	22·6	18·9	28·4	24	7·3	2	77·6	26·4
Lawrence,	New Castle,	932	...	...	...	33·6	69·0	27	6·0	6, 13	44·3	22·8	21·5	40·0	19	9·0	13	73·8	26·2
Lebanon,	Lebanon,	480	30·102	30·562	29·429	32·4	67 5	31	8·1	13	41·2	23·9	17·3	34·3	31	8·1	13	73·1	24·6
Luzerne,	Drifton— Drifton Hospital,	1,655	...	...	...	26·9	59·0	31	—5·0	13	38·5	18·5	20·0	31·0	4, 19	8·0	27, 29	...	...
Lycoming,	Williamsport,	525	...	...	...	31·9	60·0	30, 31	4·0	13	38·0	22·6	15·4	26·0	8, 25	6·0	11	77·9	26·3
McKean,	Smethport,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mercer,	Greenville— Thiel College,	1,000	30·055	30·585	29·438	28·8	67·3	19	4·0	13	39 6	20·4	19·2	39·0	19	6·0	3	79·9	23·5
Monroe,	Stroudsburg,	430	...	...	...	29·7	63·0	31	3·0	13	39·6	20·3	19·3	36·0	19	7·0	11	76·5	23·0
Montgomery,	Pottstown,	150	...	...	...	33·5	68·0	31	4 0	6	40·8	26·9	13·9	30·0	30	1·0	2	71·0	25·5
Northampton,	Bethlehem,	360	...	...	...	32·2	61·0	21	5·0	13	39·3	23·7	15·6	29·0	19	8·0	2, 11, 26	69·0	23·0
Northumberland,	Shamokin,	733	...	...	...	31·7	64·0	21	5·0	13	43·4	22·3	21·1	36·0	12	10·0	5	85·4	28·0
Perry,	New Bloomfield,	400	...	...	...	30·8	64·0	31	6·0	6	40 9	22·2	18·7	53·0	19	9·0	2, 7	...	...
Philadelphia,	Philadelphia,	117	30·081	30·570	29·360	35·1	70·0	31	8·2	13	43·4	27·0	16·4	27·5	31	6·8	13	67·1	24·3
Pike,	Blooming Grove,	800	...	...	...	28·0	59·0	28	0·5	13	...	...	...	...	...	...	...	...	...
Potter,	Coudersport,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Schuylkill,	Girardville,	1,030	30·127	30·505	29·452	30·5	59 0	31	1·0	13	37·0	21·1	15·9	26·0	19	6·0	7	...	...
Somerset,	Somerset,	2,250	...	...	...	30·0	67·0	20	1 0	13	40·6	20·5	20·1	36·0	20	5·0	13	80·6	24·2
Sullivan,	Eagles Mere,	2,060	...	...	...	30·2	51·0	21	—6·0	13	30·2	15·1	15·1	23·0	18	6·0	27	68·0	21·0
Sullivan,	Bernice,	2,200	30·279	30·675	29·675	26·1	60·0	27	—5·5	14	34·7	15·7	19·0	32·0	25	3·0	2	78·8	20·0
Susquehanna,	Montrose,	1,060	...	...	...	26·3	58·0	22	—4·0	13	31·1	16·5	14·6	37·0	22	6·0	11	...	...
Tioga,	Wellsboro,	1,327	30·076	30·498	29·313	27·6	56·0	30	—2·0	13	35·5	20·3	15·2	...	...	...	...	...	...
Venango,	Franklin,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Washington,	Scenery Hill,	1,750	...	...	...	34·0	66·0	20	6 0	13, 14	42·2	24·8	17·4	30·0	30	2·0	3	...	...
Washington,	Washington,	1,175	...	...	...	36·9	68·7	20	9·0	13, 14	43·3	27·2	16·1	36·0	19	3·0	17	...	...
Warren,	Columbus,	1,410	30·227	30·645	29·376	28·3	68·0	19	0·0	13	37·8	18·9	18·9	45·0	19	1·0	11	...	...
Wayne,	Dyberry,	1,100	...	...	...	23·4	54·0	21	—5 0	18	32·6	14·1	18·5	45·0	19	5·0	11	...	...
Westmoreland,	Greensburg,	1,075	...	...	...	34·9	70·0	20, 27	7·0	13, 14	45·0	24·5	20·5	40·1	19	8·0	17	72·8	27·0
York,	York,	385	...	...	...	33·9	69·0	31	—2·5	6	42·7	24·9	17·8	31·5	6	6·0	2	71·7	26·0

*Observations taken at 12, Noon. †Observations taken at 8 A. M. and 8 P. M.

M.	Temperature.									Relative Humidity.	Dew Point.	Precipitation.		
	Minimum.		Mean of Maximum.	Mean of Minimum.	Daily Range.									
Date.	Lowest.	Date.			Mean.	Greatest.	Date.	Least.	Date.			Total Inches.	Total Depth of Snow (inches).	Number of Days Rainfall.
20	9·1	13	46·3	27·5	18·8	36·0	19	8·4	13	71·2	27·3	2·51	. . .	15
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
0, 30	1·0	6	41·5	23·0	18·5	35·0	18	3·0	25	72·0	24·0	3·42	10·9	14
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
21	2·0	13	38·4	23·9	14·5	28·0	4	3·5	2	. . .	. . .	3·65	9·0	9
31	4·0	13	46·1	25·6	20·5	39·0	12	10·5	8	73·3	28·0	1·75	. . .	11
30	2·0	7	42·1	20·3	21·8	36·0	18	6·0	13	69·6	. . .	2·55	. . .	7
21	2·0	13	40·4	21·9	18·5	43·2	19	3·0	7	74·1	23·0	2·07	8·0	10
31	2·0	13	40·6	21·5	19·1	32·0	19	9·0	26	80·5	24·7	4·94	15·3	14
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
30	1·0	24	42·6	22·9	18·7	40·0	19	9·0	2	69·2	22·4	2·88	. . .	7
9, 31	—1·5	13	38·2	17·8	20·4	32·5	19	12·0	5, 12	81·4	24·0	2·85	. . .	10
31	0·0	13	43·2	22·1	21·1	41·0	9	2·0	20	. . .	. . .	2·06	. . .	13
31	6·0	13	40·8	24·0	16·8	28·0	30	8·0	2	68·0	23·4	6·39	13·3	17
31	—3·0	6	41·4	23·2	18·2	41·5	31	3·5	. . .	. . .	. . .	6·28	18·5	15
19	0·0	13	36·7	23·0	13·7	26·0	19	4·0	13	. . .	. . .	. . .	. . .	. . .
19	1·0	13	36·2	16·4	19·8	40·0	19	6·0	13	83·0	21·0	. . .	. . .	. . .
20	0·0	13	35·7	20·4	15·3	34·0	18, 19	6·0	7	. . .	. . .	3·00	8·0	8
31	6·0	13	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2·33	7·0	9
21	3·0	14	41·9	25·0	16·9	35·5	18	5·5	2, 3, 22	68·0	25·0	2·39	6·0	10
20	3·0	24	41·8	23·8	18·0	32·0	23	5·0	13	77·0	25·2	. . .	. . .	. . .
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
31	6·0	5	39·5	25·6	13·9	32·0	30	0·5	2	80·0	27·0	2·91	5·5	13
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
31	6·0	6	41·9	25·3	16·6	28·5	31	8·6	17	72·0	25·2	5·41	. . .	10
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
19	3·0	24	36·5	20·2	16·3	38·9	19	5·5	5, 28	76·9	20·2	2·04	. . .	16
9, 27	7·0	6	46·1	27·0	19·1	42·0	19	8·0	17	73·2	29·5	3·00	7·0	9
20	3·0	13, 24	43·2	21·1	22·1	42·0	19	10·0	16	75·2	21·4	. . .	. . .	. . .
21	—5·0	6	40·1	23·1	17·0	38·0	19	7·0	5	81·5	24·7	1·72	. . .	9
31	0·1	6	44·2	24·5	19·7	33·0	6	6·0	13	74·7	26·4	3·76	8·0	11
20	7·0	13, 14	42·9	23·8	19·1	36·0	19	10·0	2	75·9	26·7	3·26	5·5	10
20	3·0	13	40·8	23·2	17·6	36·0	19	6·0	13	86·5	28·8	3·34	2·5	14
21	0·0	13	40·4	19·4	21·0	37·0	19	10·0	13	82·6	24·2	3·01	11·5	7
21	1·5	6	41·5	22·6	18·9	28·4	14	7·3	2	77·6	26·4	4·50	12·9	11
27	6·0	6, 13	44·3	22·8	21·5	40·0	19	9·0	13	73·8	26·2	2·01	2·0	7
21	8·1	13	41·2	23·9	17·3	34·3	31	8·1	13	73·1	24·6	4·08	7·5	15
21	—5·0	13	38·5	18·5	20·0	31·0	4, 19	8·0	27, 29	. . .	. . .	3·11	. . .	7
9, 31	4·0	13	38·0	22·6	15·4	26·0	8, 25	6·0	11	77·9	26·3	3·09	4·1	7
.	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
19	4·0	13	39·6	20·4	19·2	39·0	19	6·0	3	79·9	23·5	1·92	3·0	14
21	3·0	13	39·6	20·3	19·3	36·0	19	7·0	11	76·5	23·0	3·62	13·5	10
21	4·0	6	40·8	26·9	13·9	30·0	30	1·0	2	71·0	25·5	5·35	12·0	10
21	5·0	13	39·3	23·7	15·6	29·0	19	8·0	2, 11, 26	69·0	23·0	3·84	. . .	7
21	5·0	13	43·4	22·3	21·1	36·0	12	10·0	5	85·4	28·0	3·02	1·0	9
21	6·0	6	40·9	22·2	18·7	53·0	19	9·0	2, 7	. . .	. . .	3·95	7·5	6
21	8·2	13	43·4	27·0	16·4	27·5	31	6·8	13	67·1	24·3	5·42	12·1	14
28	0·5	13	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	8
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
21	1·0	13	37·0	21·1	15·9	26·0	19	6·0	7	. . .	. . .	4·35	19·0	10
20	1·0	13	40·6	20·5	20·1	36·0	20	5·0	13	80·6	24·2	3·25	5·5	11
21	—6·0	13	30·2	15·1	15·1	23·0	18	6·0	27	68·0	21·0	4·34	20·0	7
27	—5·5	14	34·7	15·7	19·0	32·0	25	3·0	2	78·8	20·0	3·63	19·0	19
22	—4·0	13	31·1	16·5	14·6	37·0	22	6·0	11	. . .	. . .	. . .	14·4	. . .
20	—9·0	13	35·5	20·3	15·2	. . .	. . .	. . .	. . .	. . .	. . .	3·60	10·2	9
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
20	6·0	13, 14	42·2	24·8	17·4	30·0	30	2·0	3	. . .	. . .	1·58	. . .	. . .
20	9·0	13, 14	43·3	27·2	16·1	36·0	19	3·0	17	. . .	. . .	3·32	. . .	12
19	0·0	13	37·8	18·9	18·9	45·0	19	1·0	11	. . .	. . .	1·74	. . .	15
21	—5·0	18	32·6	14·1	18·5	45·0	19	5·0	11	. . .	. . .	4·01	18·7	15
27	7·0	13, 14	45·0	24·5	20·5	40·1	19	8·0	17	72·8	27·0	3·77	. . .	12
21	—9·5	6	42·7	24·9	17·8	31·5	6	6·0	2	71·7	26·0	3·78	9·5	16

CIPITATION.		NUMBER OF DAYS.			WIND.	OBSERVERS.
Total Depth of Snow (inches).	Number of Days Rainfall.	Clear.	Fair.	Cloudy.	Prevailing Direction.	
. . .	15	4	13	14	NW	Oscar D. Stewart, Sgt. Sig. Corps.
. . .	. . .	. . .	. . .	. . .	. . .	Tyson Heilman.
. . .	. . .	. . .	. . .	. . .	. . .	Hon. Hartford P. Brown.
10'9	14	6	14	11	NW	Rev. A. Thos. G. Apple.
. . .	. . .	. . .	. . .	. . .	. . .	Prof. George A. Ruddle.
9'0	9	9	. . .	. . .	. . .	Prof. J. H. Rohrbach.
. . .	11	. . .	. . .	. . .	. . .	Dr. Charles B. Dudley.
. . .	7	14	8	9	W	Prof. J. A. Stewart.
8'0	10	8	7	16	NW	Charles Beecher.
15'3	14	8	11	12	NW	J. L. Heacock.
. . .	. . .	. . .	. . .	. . .	. . .	J. E. Forsythe.
. . .	7	7	13	11	NW	T. B. Lloyd.
. . .	10	7	10	14	W	Prof. Wm. Frear.
. . .	13	3	12	14	NW	L. Ray Morgan.
13'3	17	13	8	10	NW	Jesse C. Green, D.D.S.
28'5	15	10	12	9	W	W. T. Gordon.
. . .	. . .	7	12	12	SE	Rev. W. W. Deatrick, A.M.
. . .	. . .	4	12	15	NW	J. H. Apple, A.B.
8'0	8	3	16	12	NW	Nathan Moore.
7'0	9	8	11	12	W	Prof. John A. Robb.
6'0	10	11	10	10	NW	Robert M. Graham.
. . .	. . .	. . .	. . .	. . .	N, W	Prof. J. H. Montgomery.
. . .	. . .	. . .	. . .	. . .	. . .	Prof. Charles F. Himes, Ph.D.
5'5	13	7	12	12	W	J. E. Pague.
. . .	. . .	. . .	. . .	. . .	. . .	Zenos J. Gray, M.D.
. . .	10	12	8	11	NW	Prof. Susan J. Cunningham.
. . .	. . .	. . .	. . .	. . .	. . .	Joe Messinger.
. . .	16	5	14	12	W	Peter Wood, Sgt. Sig. Corps.
7'0	9	7	15	9	NW	Wm. Hunt.
. . .	. . .	5	8	18	N	Robert L. Haslet.
. . .	9	. . .	. . .	. . .	. . .	Miss Mary A. Ricker.
8'0	11	12	10	9	N, W	Thomas F. Sloan.
8'5	10	11	12	8	W	Prof. W. J. Swigart.
8'5	14	5	9	17	W	Prof. Albert E. Maltby.
11'5	7	9	4	18	NW	T. F. Heebner, M.D.
12'9	11	9	10	12	W	A. M. Schmidt, A.B.
9'0	7	1	11	19	NW	Wm. T. Butz.
7'3	15	13	8	10	NW, SW	George W. Hayes, C.E., Ph G.
. . .	7	7	9	15	NW	H. D. Miller, M.D.
4'1	7	5	13	13	W	E. H. Baker.
. . .	. . .	. . .	. . .	. . .	. . .	Armstrong & Brownell.
3'0	14	3	12	16	NW	Prof. S. H. Miller.
13'5	10	13	8	10	NW	N. C. Miller, M.D.
12'0	10	14	6	11	NW	Charles Moore, D.D.S.
. . .	7	11	8	12	NW	Lerch & Rice.
1'0	9	9	13	9	NW	G. R. Hanley.
7'5	6	12	8	11	W	Frank Mortimer.
12'1	14	9	10	12	NW	Luther M. Dey, Sgt. Sig. Corps.
. . .	8	. . .	. . .	. . .	N	John Grathwohl.
. . .	. . .	. . .	. . .	. . .	. . .	D. W. Butterworth.
19'0	10	9	11	11	NW	E. C Wagner.
5'5	11	4	9	18	NW, SW	W. M. Schrock.
20'0	7	8	10	13	NW	E. S. Chase.
19'0	19	7	9	15	NW	C. R. Claghorn.
14'4	. . .	10	7	14	NW	A. H. Berlin.
10'2	9	2	8	21	NW	H. D. Deming.
. . .	. . .	. . .	. . .	. . .	. . .	Prof. N. P. Kinsley.
. . .	. . .	5	10	16	S	Jacob Gayman.
. . .	12	3	10	18	NW	Harrison Otis.
. . .	15	7	8	16	SW	Wm. Loveland.
18'7	15	8	5	18	NW	Theodore Day.
. . .	12	5	9	17	W	H. S. Brunot.
9'5	16	12	8	11	NW	Mrs. L. H. Grenewald.

T. F. TOWNSEND, *Sergeant Signal Corps, Assistant.*

	Erie.	Greenville.
1	.09	.05
2	.33	.25
3	. .	. .
4	. .	. .
5	. .	. .
6	. .	. .
7	. .	. .
8	. .	. .
9	. .	. .
10	. .	. .
11	.35	.71
12	.03	.01
13	.08	.06
14	.01	.01
15	. .	. .
16	. .	. .
17	. .	. .
18	. .	. .
19	. .	. .
20	.10	.05
21	.22	.08
22	.19	.01
23	.01	. .
24	. .	. .
25	.04	.08
26	.06	.28
27	.26	.16
28	.13	.04
29	.14	.13
30	. .	. .
31	. .	. .
	2.04	1.92

PRECIPITATION FOR MARCH, 1888.

	Erie.	Greenville.	New Castle.	Washington.	Pittsburgh.	Columbus.	Clarion.	Uniontown.	Indiana.	Somerset.	Grampian Hills.	Emporium.	Phillipsburg.	Hollidaysburg.	Altoona.	Charlesville.	State College.	Huntingdon.	McConnellsburg.	Lock Haven.	Williamsport.	Chambersburg.	New Bloomfield.	Carlisle.	York.	Wysox.	Eagles Mere.	Bernice.	Catawissa.	Shamokin.	Girardville.	Lebanon.	Lancaster.	Drifton.	Scranton.	Kutztown.	Pottstown.	West Chester.	Coatesville.	Dyberry.	Bloming Grove.	Bethlehem.	Quakertown.	Swarthmore.	Philadelphia.	Stroudsburg.
1	.09	.05	.15	.04	.07	.04	.08	. .	.20	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.04	. .	. .	. .	. .	.01	.12	. .	.08	.05	. .	.12	.01	. .	. .	1.00	. .	. .	. .	. .	.08	. .	. .	. .	. .	. .	.30
2	.33	.25	.18	.28	.15	.32	.36	. .	.20	. .	. .	.40	.11	.18	.03	.06	.25	.03	.05	.11	.14	. .	. .	. .	.05	.01	.12	. .	.07	.07	.08	. .	.02	.05	. .	.05	. .	. .	. .	.03	. .	.10	. .	. .	.02	. .	.02	. .
3	. .	. .	. .	. .	. .	.08	. .	.25	.13	.23	.50	. .	. .	. .	.05	.01	.	.10	.01	. .	. .	. .	. .	. .	.01	. .	. .	.09	. .	. .	. .	.01	. .	. .	. .	. .	. .	. .	.03	.02	.02	. .	.04	.09	. .	.05	. .
4	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.01	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
5	. .	. .	. .	. .	. .	. .	. .	. .	. .	.08	. .	. .	. .	. .	. .	.13	.04	.03	.30	. .	. .	. .	.20	.03	.50	. .	. .	. .	. .	. .	. .	.09	.50	. .	. .	.09	.22	.22	.32	. .	. .	.02	.04	.30	.15	. .
6	. .	. .	. .	.02	. .	.01	. .	.18	. .	. .	. .	. .	. .	. .	.02	. .	. .	. .	. .	. .	. .	. .	. .	.04	. .	. .	.01	. .	. .	. .	. .	. .	. .	. .	. .	. .	.01	.01	. .	.01	. .	. .	. .	. .	. .	. .
7	. .	. .	. .	. .	. .	. .	. .	. .	.01	. .	. .	. .	.31	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.05	. .	. .	.10	. .	. .	. .	. .	. .	. .	.01	. .	.01	. .	. .	. .	. .	. .	. .
8	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.05	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.02	. .	. .	. .	. .	. .	. .
9	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
10	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
11	.35	.71	.65	.58	.55	.47	. .	.66	.52	.45	.72	.61	.34	.98	.17	1.31	.82	1.24	1.81	.33	1.00	. .	1.20	.96	1.23	.45	1.35	.65	1.14	.96	1.07	1.40	1.58	.81	.55	.83	1.80	1.69	1.39	.30	. .	. .	1.14	1.38	1.23	.56
12	.03	.01	. .	.04	.02	.04	. .	.16	. .	. .	. .	. .	. .	.	.27	. .	. .	. .	. .	. .	. .	. .	. .	.46	.13	. .	. .	.50	. .	.05	. .	. .	. .	.65	. .	.50	.80	1.05	1.31	1.50	. .	1.44	.82	1.06	1.27	. .
13	.08	.06	. .	.04	.03	.03	. .	. .	.02	.20	. .	. .	. .	. .	. .	.01	.02	. .	. .	. .	. .	. .	. .	. .	.03	.05	.70	. .	. .	. .	.09	.01	.05	.42	. .	. .	. .	. .	.15	. .	. .	. .	. .	. .	. .	.05
14	.01	.01	. .	. .	.03	.01	. .	.06	. .	.03	. .	. .	. .	. .	. .	.01	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.40	. .	. .	. .	. .	. .	. .	. .	.16	.06	.05	.01	.05	. .	. .	.10	. .	.02	.05
15	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.36	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
16	. .	. .	.03	.38	.33	.01	. .	.44	.80	.20	.12	. .	. .	.07	. .	.10	.10	. .	. .	.24	. .	. .	. .	. .	.06	. .	. .	.01	.01	.40	. .	.05	.15	. .	. .	. .	.12	.08	.16	. .	. .	. .	.09	.10	.08	. .
17	. .	. .	. .	. .	.01	. .	. .	. .	. .	. .	. .	. .	. .	. .	.07	. .	. .	. .	. .	. .	. .	. .	. .	.04	. .	. .	. .	.01	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
18	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.04	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
19	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
20	.10	.05	. .	. .	. .	.11	.08	. .	. .	. .	.11	.10	.02	.03	.02	. .	.02	. .	.17	.04	. .	. .	.50	.15	.30	.04	.18	.11	.02	.10	.36	.31	.45	. .	.14	.62	.20	.48	.46	.08	. .	. .	.24	.50	.50	.17
21	.22	.08	.22	.35	.25	.10	.25	.29	.42	.45	.51	.40	.02	.53	.45	.85	.77	.85	.47	.75	1.10	. .	1.30	.80	.34	.47	.82	.51	.29	.38	1.27	.78	.45	1.20	.36	.34	.70	1.04	.96	.32	. .	.88	.99	.93	.87	.70
22	.19	.01	. .	.08	. .	.05	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.04	. .	. .	. .	. .	. .	.01	. .	.05	. .	. .	. .	. .	.05	. .	.02	. .	. .	.01	. .	. .	. .
23	.01	. .	. .	. .	. .	. .	. .	. .	.01	. .	. .	. .	.02	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.06	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
24	. .	. .	. .	. .	.03	. .	. .	.12	. .	. .	. .	. .	. .	. .	. .	.01	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
25	.04	.08	. .	. .	.09	. .	. .	.09	.05	. .	. .	. .	.20	. .	. .	.18	. .	.21	.05	. .	.02	. .	.25	.05	.10	.25	.04	.06	.22	. .	.51	.11	.24	.06	. .	.03	.30	.16	.20	. .	. .	. .	.19	.02	.05
26	.06	.28	.50	.39	.27	.25	.45	. .	.25	.90	.42	.47	.14	.51	.34	.28	.33	.27	.51	.13	.44	. .	.50	.63	.71	.26	.30	.38	.33	.68	.36	.87	.65	.52	.55	.63	.95	.83	.92	1.04	. .	1.18	1.13	.30	.60	1.10
27	.26	.16	. .	. .	.12	. .	. .	.02	. .	. .	. .	. .	.04	. .	. .	.15	.02	.08	.08	. .	. .	. .	. .	.08	.01	.01	. .	. .	. .	. .	.11	.05	.08	. .	. .	.45	. .	.22	.07	. .	. .	.04	.10	. .	.11	.30
28	.13	.04	.28	.12	.32	.09	.02	. .	.35	.53	.20	.24	.11	.25	.10	.10	. .	.25	.15	.26	.04	. .	. .	.10	.08	.30	.35	.30	.06	.07	. .	.06	. .	. .	. .	.50	.12	.14	.07	. .	.24	.03	.13	.07	. .
29	.14	.13	. .	1.00	.24	.13	.46	.84	.32	.13	.42	.66	.35	. .	.23	.22	.48	.20	.16	.41	.35	. .	. .	.18	.28	. .	. .	.36	.40	.30	.36	.30	.30	. .	. .	.36	. .	. .	.36	.30	.32	. .	. .	.34	.48	.41	.34
30	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
31	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
	2.04	1.92	2.01	3.32	2.51	1.74	1.70	3.00	3.34	3.93	3.00	2.88	2.06	2.55	1.73	3.42	2.85	3.26	3.76	2.33	3.09		3.95	2.91	3.78	2.07	4.34	3.63	2.59	3.00	4.35	4.08	4.50	3.11	3.01	3.65	5.35	6.39	6.28	4.01		3.84	4.04	5.41	5.42	3.62

T. F. T.

	Erie.
1	.09
2	.33
3	.
4	.
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6	.
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9	.
10	.
11	.15
12	.03
13	.08
14	.01
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16	.
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18	.
19	.
20	.12
21	.22
22	.19
23	.01
24	.
25	.04
26	.05
27	.26
28	.13
29	.14
30	.
31	.
	2.04

PRECIPITATION FOR MARCH, 1888.

	Erie.	Greenville.	New Castle.	Washington.	Pittsburgh.	Columbus.	Clarion.	Uniontown.	Indiana.	Somerset.	Grampian Hills.	Emporium.	Phillipsburg.	Hollidaysburg.	Altoona.	Charlesville.	State College.	Huntingdon.	McConnellsburg.	Lock Haven.	Williamsport.	Chambersburg.	New Bloomfield.	Carlisle.	York.	Wysox.	Eagles Mere.	Bernice.	Catawissa.	Shamokin.	Girardville.	Lebanon.	Lancaster.	Difton.	Scranton.	Kutztown.	Pottstown.	West Chester.	Coatesville.	Dyberry.	Blooming Grove.	Bethlehem.	Quakertown.	Swarthmore.	Philadelphia.	Stroudsburg.
1	.09	.05	.15	.04	.07	.04	.08	..	.20	..	..	..	..	..	..	..	..	..	..	.04	..	..	..	..	.01	.12	..	.02	.05	..	.12	.01	..	..	1.00	..	..	..	.02	..	..	..	..	..	..	.30
2	.33	.25	.18	.28	.15	.32	.36	..	.20	..	..	.40	.11	.18	.03	.06	.25	.03	.05	.11	.14	..	..	..	.05	.01	.12	..	.07	.07	.08	..	.02	.05	..	.05	..	..	.03	..	.10	..	..	.02	..	.02	..
3	..	..	..	..	..	.08	..	.25	.13	.23	.50	..	..	..	.05	.01	..	.10	.01	..	..	..	..	..	..	.01	..	..	.09	..	..	..	.01	..	..	..	..	..	..	.03	.02	.02	..	.04	.09	..	.05	..
4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.01	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
5	..	..	..	..	..	..	..	..	..	.08	..	..	..	..	..	.13	.04	.03	.30	..	..	..	..	.20	.03	.50	..	..	..	..	..	.09	.50	..	..	.09	.22	.22	.32	..	..	.02	.04	.30	.15	..
6	..	..	..	.02	..	.01	..	.18	..	..	..	..	..	..	.02	..	..	..	..	..	..	..	..	..	.04	..	..	..	.01	..	..	..	..	..	..	..	..	.01	..	.01	..	..	..	..	..	..	..
7	..	..	..	..	..	..	..	..	.01	..	..	..	.31	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.05	..	..	.10	..	..	..	..	..	..	.01	..	.01	..	..	..	..	..	..	..
8	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.05	..	..	..	..	..	..	..	..	..	..	.02	..	..	..	..	..	..	..	..
9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
11	.75	.71	.65	.58	.55	.47	..	.66	.52	.45	.72	.61	.24	.98	.17	1.31	.82	1.24	1.81	.33	1.00	..	..	1.80	.96	1.23	.45	1.35	.65	1.14	.96	1.07	1.40	1.58	.21	.55	.83	1.50	1.65	1.39	.30	..	..	1.14	1.38	1.25	.56
12	.71	.01	..	.04	.11	.04	..	.16	..	..	..	..	..	..	.27	..	..	..	..	..	..	..	..	..	.46	.13	..	..	.50	..	.05	..	..	..	.65	..	.50	.80	1.05	1.31	1.50	..	1.44	.82	1.08	1.27	..
13	.08	.06	..	.04	.03	.03	..	..	.02	.20	..	..	..	..	..	.01	.02	..	..	..	..	..	..	..	..	.03	.05	.70	..	..	.09	.01	.05	.42	..	..	..	..	..	.15	..	..	..	..	..	.05
14	.01	.01	..	..	.03	.01	..	.06	..	.03	..	..	..	..	..	.01	..	..	..	..	..	..	..	..	..	..	..	.40	..	..	..	..	..	..	.16	.06	.05	.01	.05	..	..	..	.10	..	.02	.05
15	..	..	..	..	..	..	..	..	..	..	..	..	.36	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
16	..	..	.03	.38	.33	.01	..	.44	.80	.20	.12	..	..	.07	..	.10	.10	..	..	.24	..	..	..	..	..	.06	..	.01	.01	.40	..	.05	.15	..	..	..	.12	.08	.16	..	..	.09	.10	.08	..	..
17	..	..	..	..	.01	..	..	..	..	..	..	..	..	..	.07	..	..	..	..	..	..	..	..	..	.04	..	..	.01	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
18	..	..	..	..	..	..	..	..	..	..	..	..	.04	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
19	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
20	.15	.05	..	..	..	.11	.08	..	..	..	.11	.10	.02	.03	.02	..	.02	..	.17	.04	..	..	..	.30	.15	.39	.04	.18	.11	.02	.10	.36	.31	.45	..	.14	.60	.20	.48	.46	.08	..	..	.24	.30	.50	.17
21	.28	.08	.25	.35	.25	.10	.25	.29	.42	.45	.51	.40	.02	.53	.45	.85	.77	.85	.47	.75	1.10	..	..	1.30	.20	.34	.47	.82	.51	.29	.38	1.27	.78	.45	1.20	.36	.34	.70	1.04	.96	.32	..	..	.39	.93	.87	.70
22	.19	.01	..	.08	..	.05	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.04	..	..	..	..	.01	..	.03	..	..	..	.05	..	.02	..	..	..	.01	..	..	..
23	.01	..	..	..	..	..	..	..	.01	..	..	..	.02	..	..	..	..	..	..	..	..	..	..	..	..	.06	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
24	..	..	..	..	.03	..	..	.12	..	..	..	..	..	..	..	.01	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
25	.04	.08	..	..	.09	..	..	..	.09	.05	..	..	.20	..	..	.18	..	.21	.05	..	.02	..	..	.25	.05	.10	.25	.04	.06	.22	..	.51	.11	.24	.06	..	.03	.30	.16	.20	..	..	..	.19	.02	.05
26	.06	.28	.5.	.39	.27	.25	.45	..	.25	.90	.42	47	.14	.51	.34	.28	.33	.27	.51	.15	.44	..	..	.50	.63	.71	.26	.90	.38	.33	.68	.36	.87	.65	.52	.55	.63	.95	.83	.92	1.04	..	1.18	1.13	.30	.60	1.10
27	.26	.16	..	..	.19	..	..	..	.02	..	..	..	.04	..	..	.15	.02	.08	.08	..	..	..	..	..	.08	.01	.01	..	..	..	.11	.05	.08	..	..	.45	..	.22	.07	..	..	.04	.10	..	.11	.30
28	.13	.04	.28	.12	.32	.09	.02	..	.35	.53	.20	.24	.11	.25	.10	.10	..	.25	.15	.26	.04	..	..	..	.10	.08	.30	.35	.30	.06	.07	..	.06	..	..	..	.50	.12	.14	.07	..	.24	.03	.13	.07	..
29	.14	.13	..	1.00	.24	.13	.46	.84	.32	.13	.42	.66	.35	..	.23	.22	.48	.20	.16	.41	.35	..	..	..	.12	.20	..	..	.36	.40	.30	.36	.30	.30	..	.36	..	..	.36	.30	.32	..	..	.34	.48	.41	.34
30	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
31	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	3.04	2.32	2.03	3.32	2.51	1.74	1.70	3.00	3.34	3.25	3.00	2.88	2.06	2.55	1.75	3.42	2.85	3.26	3.76	2.33	3.09			3.95	2.91	3.78	3.07	4.34	3.63	2.39	3.08	4.35	4.08	4.50	3.11	3.01	3.65	5.35	6.39	6.28	4.01		3.84	4.94	5.41	5.42	3.62

T. F T.

11th a heavy, warm rain, which had prevailed during the day from the southeast, suddenly changed to a furious snowstorm, accompanied by intense cold, and north and northwest gales.

Telegraph wires and poles were soon prostrated, railway trains were blockaded by huge snowbanks, and all communication by wire or rail was completely cut off for three days, during which time the high winds kept the snow a moving mass, which baffled all efforts to clear the roads and re-establish communication. At Philadelphia the wind attained a maximum velocity of 66 miles per hour. Reports show higher velocities along the coast in the track of the storm centre.

MISCELLANEOUS PHENOMENA.

Auroras.—Quakertown, 30th.

Solar Halos.—Lebanon, 10th; York, 10th; Eagles Mere, 5th, 25th, 27th, 31st; Dyberry, 29th; Stroudsburg, 25th; Charlesville, 10th, 27th, 30th.

Lunar Halos.—Lebanon, 19th; Indiana, 23d; Huntingdon 18th, 19th; Hollidaysburg, 19th, 20th; Grampian Hills, 24th; Girardville, 24th; Eagles Mere, 19th, 24th; Dyberry, 19th; Carlisle, 18th, 19th; Charlesville, 20th, 23d; Catawissa, 19th, 24th; Bernice, 24th; Washington, 24th, 26th; Greenville, 20th, 23d, 24th; York, 20th, 23d; Clarion, 20th, 23d, 24th; Lancaster, 14th, 18th, 19th, 23d; State College, 19th, 24th; Quakertown, 24th; Somerset, 23d; Shamokin, 24th; New Castle, 19th, 23d; Stroudsburg, 24th; Swarthmore, 19th, 24th.

Lunar Coronæ.—Lebanon, 19th, 23d; Huntingdon, 23d; Eagles Mere, 18th; Dyberry, 5th, 19th; Charlesville, 23d; Greenville, 18th; Clarion, 18th; Somerset, 20th, 24th, 26th; Shamokin, 18th; Stroudsburg, 19th, 23d.

Parhelia.—Eagles Mere, 15th; Dyberry, 15th; Clarion, 30th.

Zodiacal Lights.—Indiana, 5th; Dyberry, 4th, 9th.

Thunder Storms.—In nearly all parts of the State on 21st.

T. F. T.

WEATHER SIGNALS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
Chester Oil Company,	Chester.
C. W. Burkhart,	Shoemakerville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Werner & Son,	Emporium.

Displayman.	*Station.*
C. E. Lenhart,	Latrobe.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
S. W. Morrison,	Oxford.
Capt. A. Goldsmith,	Quakertown.
J. L. Morrison,	Sharon.
Wm. A. Engel,	Shenandoah.
Wm. Schrock,	Somerset.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
E. H. Baker,	Williamsport.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
E. S. Chase,	Eagles Mere.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
Armstrong & Brownell,	Smethport.
J. E. Forsythe,	Butler.
James H. Fones,	Tionesta.
Wister, Hacker & Savage,	Germantown.
W. J. Thompson & Co.,	Clifton Heights.
Steward M. Dreher,	Stroudsburg.
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
Hartford P. Brown,	Rochester.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.

PENNSYLVANIA STATE WEATHER SERVICE BULLETIN.

REVIEW FOR APRIL, 1888.

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, April 30, 1888.

TEMPERATURE.

The average temperature for April, 1888, deduced from the tri-daily observations was 46·5, which is normal. Found from the mean maximum and mean minimum, it was 47·2, which differs only seven-tenths from the normal. A deficiency of heat existed until the latter part of the month, when the extreme high temperatures of the 27th, 28th, 29th and 30th brought it up to the monthly average. Owing to the low temperatures of January, February and March, a deficiency for the year existed at the close of the month which made the season some ten days behind that of former years. The first week in the month was comparatively warm, but was followed by cold which continued until the 26th. The highest temperatures were recorded on the 29th and 30th, and averaged 88°·2, the extreme being 92° at York. This is probably the warmest April weather ever recorded in Pennsylvania. The lowest temperatures were Bethlehem, 12°; Coudersport, 15°; Lock Haven, 15°; Grampian Hills, 16°; Eagles Mere, 16°, and Bernice, 17°. Most of the low temperatures occurred on the 8th, 9th, 13th and 25th.

ATMOSPHERIC PRESSURE.

The barometer averaged high during the month, being ·15 above the mean, with a range of about one inch. The highest occurred on the 25th and 26th, and the lowest on the 2d.

PRECIPITATION.

The rainfall was quite evenly distributed, and averaged 2·52 inches for the State, which is a deficiency of nearly half an inch. Most of it fell during the middle of the month. The latter part of the month was quite dry. The heaviest rainfalls were on the 5th and 10th, and were attended by thunder storms, which were severe and general throughout the State on the 5th, several of the observers reporting damage by lightning. Snow fell at many

stations during the storms of the 14th and 16th, the greatest amounts being north and east of the Susquehanna River. The following are the largest totals for the month: Eagles Mere, 8·7 inches; Bernice, 7·3 inches; Dyberry, 6·5 inches; Wellsboro, 6·0 inches; Coudersport, 4·7 inches, and Montrose, 4·5 inches. Many of the Western stations had only "ground slightly covered" at any time during the month.

WIND AND WEATHER.

No violent wind storms of a general character passed over the State during April. The prevailing direction of wind was Northwest. The month was characterized by a large percentage of clear and fair days, and unusually low humidity. Frosts were numerous, but owing to the backwardness of the season they did but little damage. The warm weather at the close of the month gave vegetation a vigorous start.

Average number.—Rainy days, 8; clear days, 14; fair days, 10; cloudy days, 6.

MISCELLANEOUS PHENOMENA.

Thunder Storms.—Coudersport, 1st, 5th; Tionesta, 2d, 5th; Wellsboro, 2d, 5th; Lebanon, 5th; Uniontown, 5th; New Castle, 1st, 5th; Emporium, 1st, 2d, 5th; Quakertown, 5th; Charlesville, 5th, 10th, 30th; Catawissa, 5th, 10th, 30th; Erie, 1st, 2d, 5th, 10th; Rochester, 5th; York, 5th, 6th; Girardville, 5th, 30th; Shamokin, 5th, 6th, 30th; Kutztown, 5th; Johnstown, 5th; Scranton, 5th, 30th; Hollidaysburg, 5th; Lancaster, 5th; Bernice, 5th, 30th; West Chester, 5th; Washington, 2d, 5th; Somerset, 5th, 6th, 10th; Phillipsburg, 5th; Huntingdon, 5th; Swarthmore, 5th; Coatesville, 5th; Dyberry, 5th; Indiana, 5th, 10th; Montrose, 5th; Blooming Grove, 5th; Pittsburgh, 5th, 10th; Philadelphia, 6th; Carlisle, 5th, 6th; New Bloomfield, 5th, 6th, 30th; Clarion, 2d, 5th, 6th, 18th; Greenville, 1st, 5th; Grampian Hills, 2d, 5th, 30th; State College, 5th, 10th; Stroudsburg, 5th; Eagles Mere, 5th, 30th.

Hail.—Uniontown, 10th; New Castle, 5th; Emporium, 1st; Charlesville, 5th, 10th, 15th, 20th; Erie, 2d; Bernice, 12th; Somerset, 6th; Dyberry, 10th; Indiana, 10th; Greenville, 5th, 17th.

Frosts.—Charlesville, 4th, 9th, 17th, 19th, 25th, 26th; Uniontown, 1st, 9th, 24th, 28th; Emporium, 3d, 9th, 13th, 17th, 19th, 22d, 23d, 24th, 25th, 26th; Lebanon, 9th, 26th; Catawissa, 1st, 3d, 7th, 9th, 13th, 17th, 24th, 25th; York, 1st, 9th, 19th, 22d, 25th, 26th; Rochester, 3d, 4th, 8th, 19th, 26th; Johnstown, 1st, 4th, 9th, 12th, 13th, 14th, 15th, 17th, 25th, 26th, 27th; Hollidaysburg, 9th, 19th; Somerset, 13th; Erie, 3d, 4th, 8th, 9th, 13th, 15th, 17th, 23d, 25th; Indiana, 9th; Pittsburgh, 3d, 4th, 8th, 9th, 13th, 15th, 17th, 23d, 24th, 25th; Carlisle, 9th, 26th; Philadelphia, 1st, 2d, 3d, 4th, 8th, 9th, 12th, 13th, 17th, 19th, 21st, 23d, 24th, 25th; North Bloomfield, 25th, 26th; Clarion, 3d, 4th, 8th, 9th, 13th, 17th, 22d, 24th; Grampian Hills, 3d, 8th, 9th, 19th, 24th; Greenville, 3d, 4th, 8th, 9th, 13th, 15th, 23d, 24th, 25th; State College, 7th, 8th, 13th; Eagles Mere, 9th, 17th, 25th.

PRECIPITATION FOR APRIL, 1888.

	Erie.	Meadville.	Greenville.	New Castle.	Rochester.	Washington.	Pittsburgh.	Columbus.	Clarion.	Uniontown.	Indiana.	Somerset.	Johnstown.	Grampian Hills.	Emporium.	Phillipsburg.	Hollidaysburg.	Altoona.	Charlesville.	State College.	Huntingdon.	McConnellsburg.	Lock Haven.	New Bloomfield.	Carlisle.
1	.01	. .	. .	. .	. .	. .	. .	.02	. .	. .	. .	. .	. .	. .	.04	. .	. .	. .	. .	.03	. .	. .	.05	. .	. .
2	.32	.50	.36	. .	. .	. .	.01	.26	.09	. .	.02	.03	.03	.05	.19	. .	. .	. .	. .	. .	. .	. .	.02	. .	. .
3	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
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5	.88	1.42	.89	1.29	.04	.02	.07	.80	.49	.10	.30	.01	.60	.40	1.00	. .	.84	.33	.22	.46	.30	.28	1.25	.50	.43
6	.02	. .	. .	. .	.25	.40	.18	.55	.95	. .	.28	.95	.46	.46	.64	.07	.52	.53	.48	.66	.48	.53	.34	1.00	.50
7	. .	. .	. .	. .	. .	. .	. .	. .	. .	.42	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
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10	.78	.38	.55	.36	.22		.17	.70	.55	.47	1.05	.17	1.18	.46	.57	.02	.56	.50	.95	.69	.97	1.13	.20	1.00	.57
11	.06	.05	.02	.50	. .	. .	.15	.20	.08	. .	. .	. .	.22	. .	.17	.20	. .	.50	. .	. .	. .	. .	.03	. .	.66
12	. .	. .	. .	. .	.10	. .	.15	. .	. .	. .	.21	.13	.10	.14	. .	.05	.12	.17	.05	.10	.17	.03	. .	. .	.02
13	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
14	.01	. .	.08	. .	.07	. .	.02	.03	.06	. .	.30	.41	.22	.21	.16	.13	.05	.09	. .	.12	.07	.18	.06	.02	.03
15	.04	. .	.11	. .	.02	. .	.02	.02	. .	. .	.02	.11	.14	. .	. .	. .	. .	. .	.15	. .	. .	.08	. .	.03	. .
16	.12	.36	.05	. .	. .	. .	. .	.18	.12	. .	.03	. .	.02	.11	. .	.26	. .	.08	.01	.26	.22	.08	.25	. .	.36
17	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
18	.10	. .	.29	.25	.20	. .	.12	.22	.35	. .	.35	. .	.15	.24	. .	.14	. .	. .	. .	.03	. .	. .	. .	. .	.01
19	.14	. .	.16	.23	.21	. .	.09	.09	. .	.18	.15	. .	.05	.20	.02	.12	. .	. .	. .	.23	. .	. .	.19	. .	. .
20	. .	. .	.01	. .	. .	.35	.10	.05	.13	.08	.25	.23	.06	. .	.12	.18	.29	.14	.12	.21	.45	.15	.12	.20	.21
21	. .	. .	. .	. .	.08	.14	.05	. .	. .	.07	. .	.25	.05	. .	. .	.11	. .	. .	.01	. .	. .	. .	. .	. .	. .
22	. .	. .	. .	. .	. .	.08	.03	. .	. .	. .	. .	.13	.05	. .	. .	. .	. .	. .	.11	. .	. .	.04	. .	. .	. .
23	. .	. .	. .	. .	. .	. .	.01	. .	. .	.10	. .	.10	. .	. .	. .	. .	. .	. .	.04	. .	. .	.04	. .	. .	. .
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30	.22	. .	.21	.32	. .	. .	.02	.18	. .	. .	.02	. .	.01	. .	. .	.03	. .	. .	. .	. .	. .	. .	. .	. .	. .
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	2.70	2.71	2.73	2.95	1.19	0.99	1.04	3.30	2.82	1.42	2.98	2.54	3.24	2.27	2.91	1.31	2.38	2.34	2.14	2.79	2.66	2.54	2.52	2.75	2.79

	Wyoz.	Eagles Mere.	Bernice.	Catawissa.	Shamokin.	Girardville.	Lebanon.	Lancaster.	Montrose.	Drifton.	Scranton.	Kutztown.	Pottstown.	West Chester.	Coatesville.	Dyberry.	Bloming Grove.	Bethlehem.	Quakertown.	Swarthmore.	Philadelphia.	Stroudsburg	Coudersport.
1	.25	.22	.10	.01	. .	. .	.01	. .	. .	. .	.03	. .	. .	. .	. .	.08	. .	. .	.02	. .	. .	.01	. .
2	. .	. .	.02	. .	. .	. .	.01	. .	.25	. .	. .	. .	. .	.02	. .	. .	. .	. .	. .	. .	. .	. .	. .
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5	.61	1.14	.80	1.50	.78	1.61	.42	.49	.51	1.45	1.00	.08	.80	.35	.33	1.00	. .	1.67	1.17	.34	.41	1.31	1.30
6	. .	. .	.10	. .	.44	. .	.74	.23	.96	. .	.02	.43	. .	.16	.21	.38	1.60	. .	.65	.12	.09	.36	. .
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10	.05	.72	.45	.45	.31	.82	1.15	.67	. .	.65	.12	. .	1.20	.92	.52	.42	.90	1.05	1.48	1.37	.61	1.22	. .
11	. .	. .	.12	. .	. .	. .	.06	. .	.29	. .	.01	.05	. .	.04	.03	.40	. .	. .	.08	.01	.03	. .	.50
12	.07	. .	.05	.15	.05	. .	.10	.03	. .	.18	. .	.07	.12	.05	.08	. .	. .	. .	.09	. .	. .	.01	. .
13	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.06	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.20
14	.15	.31	.10	.11	.02	.06	.05	.07	.20	.12	.23	. .	. .	.08	.10	.18	.20	. .	.08	. .	.04	.06	.20
15	.10	. .	. .	. .	. .	. .	. .	.39	. .	. .	. .	.10	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
16	. .	.31	.51	.40	.26	.19	.47	.02	.16	.28	.30	.25	.60	.61	.56	.15	. .	.47	.48	.54	.58	.23	.30
17	.04	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
18	. .	.06	.45	.02	. .	. .	.01	. .	.19	. .	.07	. .	. .	. .	. .	.18	.10	. .	. .	. .	. .	. .	.30
19	.35	.61	.25	.25	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
20	. .	.10	.16	. .	. .	.44	.10	.11	.69	. .	.27	.22	.15	.10	.07	.17	. .	.13	.18	.11	.16	.16	.20
21	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.02	. .	. .	. .	. .	. .	. .	. .
22	. .	. .	. .	. .	. .	. .	. .	.01	. .	. .	. .	. .	. .	.15	.12	. .	. .	. .	. .	.15	.18	. .	. .
23	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
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30	.20	. .	.02	.02	.27	.17	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
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	1.91	3.47	3.03	2.91	2.13	3.89	3.12	2.02	3.25	2.68	2.05	2.16	2.87	2.48	2.02	2.98	2.80	3.32	4.23	2.64	2.10	3.36	3.00

T. F. T.

Coun

Allegheny
Beaver,
Bedford,
Berks, .

Berks, .

Blair, .
Blair, .
Bradford,
Bucks, .
Butler,
Cambria,
Cameron,
Centre, .

Centre, .
Chester,
Chester,
Clarion,
Clarion,

Clearfield,
Clinton,
Columbia,
Crawford,

Cumberla
Delaware,

Elk, . .
Erie, . .
Fayette,
Forest, .
Franklin,

Fulton, .
Huntingd

Indiana,

Lackawa
Lancaster

Lawrence
Lebanon,
Luzerne,

Lycoming
McKean,
Mercer,

Monroe,
Montgom
Northamp
Northumb
Perry,
Philadelp
Pike, . .
Potter, .
Schuylkill
Somerset,
Sullivan,
Sullivan,
Susquehan
Tioga, .
Venango,
Washingt
Washingt
Warren,
Wayne,
Westmore
York,

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Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weathe

County.	Station.	Elevation above Sea Level (feet).	Barometer.			Temperature.													Relative Humidity.	Dew Point.
							Maximum.		Minimum.				Daily Range.							
			Mean.	Highest.	Lowest.	Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.	Least.	Date.			
Allegheny,	Pittsburgh,	847	30·119	30·570	29·550	50·5	86·0	29	25·5	8	61·6	38·9	22·7	38·1	1	8·5	20	61·0	36·0	
Beaver,	Rochester,	821	. . .	. . .	. . .	45·6	87·0	29	22·0	8, 13	60·7	34·1	26·6	45·0	26	12·0	14	80·5	45·2	
Bedford,	Charlesville,	1,500	. . .	. . .	. . .	47·3	84·5	29	20·0	25	60·1	33·8	26·3	48·0	26	10·0	20	61·8	34·0	
Berks,	Reading— Selwyn Hall School,		. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
Berks,	Kutztown— Keystone State Normal School,	1,500	. . .	. . .	. . .	44·8	90·5	30	27·0	8	53·7	38·6	15·1	36·4	30	3·8	11	. . .	. . .	
Blair,	Altoona,	1,209	. . .	. . .	. . .	49·1	84·0	30	25·0	13	60·3	38·1	22·2	33·0	27	12·0	11	59·3	34·5	
Blair,	Hollidaysburg,	947	. . .	. . .	. . .	47·2	89·0	29	20·0	25	61·8	31·7	30·1	57·0	26	8·0	20	57·2	32·5	
Bradford,	Wysox,	718	. . .	. . .	. . .	42·6	84·5	29, 30	23·0	13	56·2	33·3	22·9	42·5	27	7·0	10	65·4	31·5	
Bucks,	Quakertown,	536	30·080	30·580	29·640	46·1	87·0	29	23·0	9	58·5	34·0	24·5	47·0	28	10·0	20	64·9	34·7	
Butler,	Butler,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
Cambria,	Johnstown,	1,184	30·107	30·420	29·630	46·5	89·0	29	21·0	25	62·0	32·6	29·4	51·0	27	15·0	20	59·9	33·2	
Cameron,	Emporium,	1,030	. . .	. . .	. . .	47·6	85·0	28, 29	20·0	25, 26	58·3	30·7	27·6	56·0	26	11·0	21	59·4	34·2	
Centre,	State College— Agricultural Experiment Station,	1,191	30·154	30·597	29·588	46·9	85·0	29, 30	20·0	13	56·0	33·7	22·3	37·0	28	9·0	14	63·3	35·5	
Centre,	Phillipsburg,	1,350	. . .	. . .	. . .	40·9	85·0	29	19·0	13. 14	57·6	32·0	25·6	47·0	28, 29	11·0	5, 10	. . .	. . .	
Chester,	West Chester,	455	30·128	30·585	29·587	48·0	86·0	29, 30	28·0	8	58·5	37·8	20·7	32·5	27	9·5	11	54·9	32·8	
Chester,	Coatesville,	380	. . .	. . .	. . .	47·3	91·0	29	24·0	9	61·0	35·6	25·4	51·5	28	12·0	10	. . .	. . .	
Clarion,	Rimersburg,	1,500	. . .	. . .	. . .	47·6	84·0	28	25·0	12	54·3	42·4	13·9	2·4	26	3·0	18	. . .	. . .	
Clarion,	Clarion— State Normal School,	1,530	. . .	. . .	. . .	44·0	81·8	28	20·0	8	51·3	36·2	15·1	36·0	27	5·5	21	65·6	32·7	
Clearfield,	Grampian Hills,	1,450	30·130	30·530	29·730	43·1	84·0	28	16·0	8	54·0	32·0	22·0	46·0	26	4·0	14	. . .	. . .	
Clinton,	Lock Haven,	560	. . .	. . .	. . .	47·6	91·5	29	15·0	21	63·2	31·3	21·9	50·0	27	10·0	14	70·0	39·0	
Columbia,	Catawissa,	491	. . .	. . .	. . .	52·0	89·5	28, ·9	26·0	9	59·9	36·7	23·2	45·0	27	7·0	20	54·3	36·0	
Crawford,	Meadville— Allegheny College,	1,252	30·148	30·506	29·691	56 6	85·0	28, 29	23·0	8, 13	56·6	32·7	23·9	43·0	28	8·0	20	69·2	46·8	
Cumberland,	Carlis e,	480	. . .	. . .	. . .	48·7	88·5	30	29·2	13	60·1	39·3	20·8	39·0	28	5·5	10	74·8	41·2	
Delaware,	Swarthmore— Swarthmore College,	190	30·123	30·548	29·660	48·4	86·9	29	27·8	9	59·3	37·9	21·4	38·5	28	10·5	11	54·2	34·8	
Elk,	Ridgway,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
Erie,	Erie,	681	30·140	30 580	29·520	41·8	73·0	29	22·5	8	50·4	34·7	15·7	29·4	5	6·4	20	66·7	32·0	
Fayette,	Uniontown,	1,000	30·109	30·461	29·617	50·5	86·0	30	25·0	25	61·9	37·1	32·8	45·0	1	6·0	20	72·4	42·2	
Forest,	Tionesta,	1,058	. . .	. . .	. . .	43·0	85·0	28	18·0	13	60·3	32·3	28·0	31·0	27	5·0	20	71·2	34·2	
Franklin,	Chambersburg— Wilson Female College,*	618	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
Fulton,	McConnellsburg,	875	. . .	. . .	. . .	48·7	87 0	29	23·0	25	62·3	35·6	26·9	48·0	27	12·0	6	60·1	35·7	
Huntingdon,	Huntingdon— The Normal College,	650	. . .	. . .	. . .	47·9	83·0	29	21·0	25	61·1	32·9	28·2	55·0	26	10·0	10	65·5	36·8	
Indiana,	Indiana— State Normal School,	1,350	. . .	. . .	. . .	47·3	84·0	28	19·5	13	58·9	34·1	24·8	40·0	28	10·5	14	69·5	37·3	
Lackawanna,	Scranton,	750	. . .	. . .	. . .	45 7	88·0	29	23·0	9	56·7	34·2	22·5	50·5	27	9·5	10	70·3	36·5	
Lancaster,	Lancaster— Franklin and Marshall College,	413	30·137	30·992	29·586	48·1	88·0	30	24·5	15	60·4	37·1	23·3	40·5	28	12·0	11	62·1	35·7	
Lawrence,	New Castle,	932	. . .	. . .	. . .	49·5	86·0	29	20·0	25	60·3	33·1	27·2	46·0	26	11·0	13	62·3	37·2	
Lebanon,	Lebanon,	480	30·148	30·627	29·611	48·3	89·3	30	26·0	9	59·9	35·6	24·3	46·6	28	8·9	10	63·5	36·0	
Luzerne,	Drifton— Drifton Hospital,	1,655	. . .	. . .	. . .	42·5	87·0	29, 30	20·0	13	55·3	32·4	22·9	41·0	28	13·0	22	. . .	. . .	
Lycoming,	Williamsport,	525	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
McKean,	Smethport,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
Mercer,	Greenville— Thiel College,	1,000	30·056	30·423	29·331	43·2	83·8	29	20·0	13	56 7	31·5	25·2	43·4	26	8·8	20	74·5	35·4	
Monroe,	Stroudsburg,	430	. . .	. . .	. . .	45·9	89·0	29	23·0	9	59·6	33·3	26·3	50·0	28	13·0	15	67·7	36·0	
Montgomery,	Pottstown,	150	. . .	. . .	. . .	49·7	90·0	30	23·0	9	60·8	38·8	22·0	40·0	28	10·0	10	62·7	37·5	
Northampton,	Bethlehem,	360	30·081	30·496	29·590	48·8	88·0	30	12·0	18	58·8	35·4	23·4	47·0	28	3·0	23	57·7	34·0	
Northumberland,	Shamokin,	733	. . .	. . .	. . .	47·0	87·0	30	21·0	10	60·0	33·3	26·7	48·0	27	14·0	21	61·7	34·0	
Perry,	New Bloomfield,	400	. . .	. . .	. . .	46·4	89·0	29. 30	23·0	9	59·4	32·7	26·7	51·0	28	10·0	10	61·0	33·3	
Philadelphia,	Philadelphia,	117	30·127	30·590	29·570	50·7	90·7	30	31·0	13	60·3	41·8	18·5	33·6	28	8·0	11, 20	53·1	32·8	
Pike,	Blooming Grove,	800	. . .	. . .	. . .	43·8	89·0	29	24·0	8	53·8	37·6	16·2	32·0	9	2·0	20	. . .	. . .	
Potter,	Coudersport,†	. . .	. . .	. . .	. . .	43·0	84·0	30	15·0	13	52·9	28 o	24·9	45·0	28	8·0	15	64·7	31·7	
Schuylkill,	Girardville,	1,030	30·015	30·718	29·733	46·3	85·0	30	25 0	9, 24	59·0	35·1	23·9	40·0	27	9·0	10	. . .	. . .	
Somerset,	Somerset,	2,250	. . .	. . .	. . .	43·4	83·5	28	18·0	13	59·0	31·0	28·0	48·0	27	14·5	21	74·9	35·7	
Sullivan,	Eagles Mere,	2,060	. . .	. . .	. . .	41·6	78·0	29, 30	16·0	9. 13	47·8	27·9	19·9	36·0	27	8·0	14	53·6	25·8	
Sullivan,	Bernice,	2,200	. . .	. . .	. . .	40·6	82·0	30	17·0	9	50·9	29·6	21·3	42·0	26	8·0	10	70·5	32·7	
Susquehanna,	Montrose,	1,060	. . .	. . .	. . .	46·1	84·0	30	18·0	8	50·9	34·1	16·8	32·0	26	7·0	2, 4	. . .	. . .	
Tioga,	Wellsboro,	1,327	30·097	30·461	29·517	42·1	84·0	29	24 0	8	53·1	34·0	19·1	42·1	29	3·3	10	74·1	36·4	
Venango,	Franklin,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
Washington,	Scenery Hill,	1,750	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
Washington,	Washington,	1,175	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
Warren,	Columbus,	1,410	. . .	. . .	. . .	50·6	83·0	28. 29	24·0	13. 25	60·2	36·9	23·3	41·7	26	8·5	18	. . .	. . .	
Wayne,	Dyberry,	1,100	. . .	. . .	. . .	42·0	84·0	29	18·0	13. 25	54·7	29·1	25·6	50·0	26	2·0	14	. . .	. . .	
Westmoreland,	Greensburg,	1,075	. . .	. . .	. . .	40·3	84·0	29, 30	17 0	9	51·1	29·0	22·1	50·0	27	3·0	10	. . .	. . .	
York,	York,	385	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
						51·9	92·0	30	22 5	1	61·7	36·3	25·4	42·5	27, 28	11·5	3	59·3	37·0	

* Observations taken at 8 A. M. and 8 P. M. † From 3d to 30th.

TEMPERATURE.												PRECIPITATION.		
MUM.	MINIMUM.				DAILY RANGE.									
Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.	Least.	Date.	Relative Humidity.	Dew Point.	Total Inches.	Total Depth of Snow (inches).	Number of Days
29	25·5	8	61·6	38·9	22·7	38·1	1	8·5	20	61·0	36·0	1·04	. . .	
29	22·0	8, 13	60·7	34·1	26·6	45·0	26	12·0	14	80·5	40·2	1·19	. . .	
29	20·0	25	60·1	33·8	26·3	48·0	26	10·0	20	61·8	34·0	2·14	0·5	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
30	27·0	8	53·7	38·6	15·1	36·4	30	3·8	11	. . .	. . .	2·16	2·5	
30	25·0	13	60·3	38·1	22·2	33·0	27	12·0	11	59·3	34·5	2·34	. . .	
29	20·0	25	61·8	31·7	30·1	57·0	26	8·0	20	57·2	32·5	2·38	. . .	
29, 30	23·0	13	56·2	33·3	22·9	49·5	27	7·0	19	65·4	31·5	1·62	. . .	
29	23·0	9	58·5	34·0	24·5	47·0	28	10·0	20	64·9	34·7	4·23	2·5	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
29	21·0	25	62·0	32·6	29·4	51·0	27	15·0	20	59·9	33·2	3·24	. . .	
28, 29	20·0	25, 26	58·3	30·7	27·6	56·0	26	11·0	21	59·4	34·2	2·91	. . .	
29, 30	20·0	13	56·0	33·7	22·3	37·0	28	9·0	14	63·3	35·5	2·79	0·5	
29	19·0	13, 14	57·6	32·0	25·6	47·0	28, 29	11·0	5, 10	. . .	. . .	1·31	0·5	
29, 30	28·0	8	58·5	37·8	20·7	32·5	27	9·3	11	54·9	32·8	2·48	0·3	
29	24·0	9	61·0	35·6	25·4	51·5	28	12·0	10	. . .	. . .	2·02	1·0	
28	25·0	12	54·3	40·4	13·9	2·4	26	3·0	18	. . .	. . .	. . .	. . .	
28	20·0	8	51·3	36·2	15·1	36·0	27	5·5	21	69·6	32·7	2·82	. . .	
28	16·0	8	54·0	32·0	22·0	46·0	26	4·0	14	. . .	. . .	2·27	0·5	
29	15·0	21	63·2	31·3	21·9	50·0	27	10·0	14	70·0	39·0	2·51	. . .	
28, 29	26·0	9	59·9	36·7	23·2	45·0	27	7·0	20	54·3	36·0	2·91	. . .	
28, 29	23·0	8, 13	56·6	32·7	23·9	43·0	28	8·0	20	69·2	46·8	2·71	. . .	
30	29·2	13	60·1	39·3	20·8	39·0	28	5·5	10	74·8	41·2	2·79	. . .	
29	27·8	9	59·3	37·9	21·4	38·5	28	10·5	11	54·2	34·8	2·64	. .	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
29	22·5	8	50·4	34·7	15·7	29·4	5	6·4	20	66·7	32·0	2·70	. .	
30	25·0	25	61·9	37·1	32·8	45·0	1	6·0	20	72·4	42·2	1·41	. . .	
28	18·0	13	60·3	32·3	28·0	31·0	27	5·0	20	71·2	34·2	. . .	. . .	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
29	23·0	25	62·5	35·6	26·9	48·0	27	12·0	6	65·1	35·7	2·54	. . .	
29	21·0	25	61·1	32·9	28·2	55·0	26	10·0	10	65·5	36·8	2·66	. . .	
28	19·5	13	58·9	34·1	24·8	40·0	28	10·5	14	69·5	37·3	2·98	. . .	
29	23·0	9	56·7	34·2	22·5	50·5	27	9·5	10	70·3	36·5	2·05	1·0	
30	24·5	15	60·4	37·1	23·3	40·5	28	12·0	11	62·1	35·7	2·02	0·5	
29	30·0	25	60·3	33·1	27·2	46·0	26	11·0	13	62·3	37·2	2·95	. . .	
30	26·0	9	59·9	35·6	24·3	46·6	28	8·9	10	63·5	36·0	3·12	2·1	
29, 30	20·0	13	55·3	32·4	22·9	41·0	28	13·0	22	. . .	. . .	2·68	. . .	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
29	20·0	13	56·7	31·5	25·2	43·4	26	8·8	20	74·5	35·4	2·73	. . .	
29	23·0	9	59·6	33·3	26·3	50·0	28	13·0	15	67·7	36·0	3·36	1·5	
30	23·0	9	60·8	38·8	22·0	40·0	28	10·0	10	61·7	37·5	2·87	. . .	
30	12·0	18	58·8	35·4	23·4	47·0	28	3·0	23	57·7	34·0	3·32	. . .	
30	21·0	10	60·0	33·3	26·7	48·0	27	14·0	21	61·7	34·0	2·13	. . .	
29, 30	23·0	9	59·4	32·7	26·7	51·0	28	10·0	10	61·0	33·3	2·75	. . .	
30	31·0	13	60·3	41·8	18·5	33·6	28	8·0	11, 20	53·1	32·8	2·10	0·5	
29	24·0	8	53·8	37·6	16·2	32·0	9	2·0	20	. . .	. . .	2·80	3·0	
30	15·0	13	52·9	28·0	24·9	45·0	28	8·0	15	64·7	31·7	3·00	4·7	
30	25·0	9, 24	59·0	35·1	23·9	40·0	27	9·0	10	. . .	. . .	3·89	3·5	
28	18·0	13	59·0	31·0	28·0	48·0	27	14·5	21	74·9	35·7	2·54	3·7	
29, 30	16·0	9, 13	47·8	27·9	19·9	36·0	27	8·0	14	53·6	25·8	3·47	8·7	
30	17·0	9	50·9	29·6	21·3	42·0	26	8·0	10	76·5	32·7	3·03	7·3	
30	18·0	8	50·9	34·1	16·8	32·0	26	7·0	2, 4	. . .	. . .	3·25	4·5	
29	24·0	8	53·1	34·0	19·1	42·1	29	3·3	10	74·1	36·4	2·49	6·0	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
28, 29	24·0	13, 25	60·2	36·9	23·3	41·7	26	8·5	18	. . .	. . .	0·99	. . .	
29	18·0	13, 25	54·7	29·1	25·6	50·0	26	2·0	14	. . .	. . .	3·30	. . .	
29, 30	17·0	9	51·1	29·0	22·1	50·0	27	3·0	10	. . .	. . .	2·98	6·5	
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	
30	22·5	1	61·7	36·3	25·4	42·5	27, 28	11·5	3	59·3	37·0	1·17	. . .	

Precipitation.			Number of Days.			Wind.	Observers.
Total Inches.	Total Depth of Snow (inches).	Number of Days Rainfall.	Clear.	Fair.	Cloudy.	Prevailing Direction.	
04	. . .	14	9	11	10	N, W	Oscar D. Stewart, Sgt. Sig. Corps.
19	. . .	9	9	13	8	W	Hon. Hartford P. Brown.
14	0'5	10	17	7	6	N	Rev. A. Thos. G. Apple.
. .	. . .	. . .	. . .	. . .	. . .	. . .	Prof. George A. Ruddle.
16	2'5	8	. . .	. . .	. . .	. . .	Prof. J. H. Rohrbach.
24	. . .	8	. . .	. . .	. . .	. . .	Dr. Charles B. Dudley.
38	. . .	6	17	11	2	W	Prof. J. A. Stewart.
82	. . .	9	11	11	8	NW	Charles Beecher.
93	2'5	9	16	9	5	NW	J. L. Heacock.
. .	. . .	. . .	. . .	. . .	. . .	. . .	J. E. Forsythe.
24	. . .	15	16	8	6	NW	E. C. Lorentz.
91	. . .	9	14	9	7	NW	T. B. Lloyd.
79	0'5	10	13	11	6	W	Prof. Wm. Frear.
31	0'5	11	17	5	8	SW	L. Ray Morgan.
48	0'3	10	16	9	5	NW	Jesse C. Green, D.D.S.
00	1'0	9	16	11	3	W	W. T. Gordon.
. .	. . .	. . .	6	18	6	NW	Rev. W. W. Deatrick, A.M.
82	. . .	8	16	10	4	W	C. M. Thomas, B.S.
97	0'5	9	14	12	4	W	Nathan Moore.
51	. . .	10	12	13	5	W	Prof. John A. Robb.
91	. . .	9	14	12	4	W	Robert M. Graham.
71	. . .	5	. . .	. . .	. . .	W	Prof. J. H. Montgomery.
79	. . .	9	13	14	3	W	J. E. Pague.
64	. .	7	14	13	3	N, W	Prof. Susan J. Cunningham.
. .	. . .	. . .	. . .	. . .	. . .	. . .	Joe Messinger.
70	. .	12	12	10	8	N, W	Peter Wood, Sgt. Sig. Corps.
42	. . .	7	17	9	4	NW	Wm. Hunt.
. .	. . .	. . .	8	14	8	NW	Robert L. Haslet.
. .	. . .	. . .	. . .	. . .	. . .	. . .	Miss Mary A. Ricker.
54	. . .	10	17	10	3	W	Thomas F. Sloan.
66	. . .	7	12	13	5	W	Prof. W. J. Swigart.
98	. . .	12	10	10	10	NW	Prof. Albert E Maltby.
05	1'0	. . .	. . .	. . .	. . .	. . .	T. F. Heebner, M.D.
02	0'5	9	10	17	3	W	A. M. Schmidt, A.B.
95	. . .	6	9	10	11	NW	Wm. T. Butz.
12	2'1	11	15	12	3	NW	George W. Hayes, C.E., Ph.G.
68	. . .	5	12	13	5	NW	H. D. Miller, M.D.
. .	. . .	. . .	. . .	. . .	. . .	. . .	E. H. Baker.
. .	. . .	. . .	. . .	. . .	. . .	. . .	Armstrong & Brownell.
73	. . .	11	8	12	10	NW	Prof S. H. Miller.
30	1'5	8	13	7	10	NW	N. C. Miller, M.D.
87	. . .	5	19	7	5	W, NW	Charles Moore, D.D.S.
32	. . .	4	14	9	7	NW	Lerch & Rice.
13	. . .	7	12	12	6	NW	G. R. Hanley.
75	. . .	6	21	7	3	W	Frank Mortimer.
10	0'5	8	14	10	6	NW	Luther M. Dey, Sgt. Sig. Corps.
80	3'0	4	13	10	7	W	John Grathwohl.
00	4'7	7	. . .	. . .	. . .	NW	D. W. Butterworth.
89	3'5	6	17	7	6	NW	E. C Wagner.
54	3'7	11	13	11	6	NW	W. M. Schrock.
47	8'7	8	13	10	7	NW	E. S. Chase.
03	7'3	13	10	13	7	NW	C. R. Claghorn.
25	4'5	8	13	11	6	NW	A. H. Berlin.
49	6'0	10	11	9	10	NW	H. D. Deming.
. .	. . .	. . .	. . .	. . .	. . .	. . .	Prof. N. P. Kinsley.
. .	. . .	. . .	. . .	. . .	. . .	. . .	Jacob Gayman.
99	. . .	5	12	12	6	NW	Harrison Otis.
30	. . .	13	14	7	9	SW	Wm. Loveland.
98	6'5	10	10	14	6	NW	Theodore Day.
. .	. . .	. . .	. . .	. . .	. . .	. . .	H. S. Brunot.
17	. . .	8	14	12	4	NW	Mrs. L. H. Grenewald.

T. F. TOWNSEND, *Sergeant Signal Corps, Assistant.*

Auroras.—Catawissa, 11th; Kutztown, 2d; Bernice, 6th; Dyberry, 11th; Montrose, 6th, 11th; Greenville, 2d; Grampian Hills, 2d; State College, 2d; Stroudsburg, 2d, 11th; Eagles Mere, 3d, 11th.

Solar Halos.—Charlesville, 4th, 13th, 15th, 17th, 23d; York, 13th; Dyberry, 17th; Eagles Mere, 1st, 6th, 17th, 19th.

Lunar Halos.—Lebanon, 22d; New Castle 17th; Quakertown, 22d; Charlesville, 17th; Erie, 3d, 4th, 9th, 18th, 22d; Greenville, 22d; Hollidaysburg, 22d; Lancaster, 19th, 20th, 21st, 22d, 23d, 24th, 25th, 26th; Bernice, 18th; Somerset, 17th; Phillipsburg, 17th; Indiana, 17th, 23d; State College, 22d.

Lunar Coronæ.—Lebanon, 18th, 22d; Charlesville, 23d; Greenville, 21st, 22d; Eagles Mere, 22d.

Parhelia.—Dyberry, 17th, 19th. T. F. T.

WEATHER SIGNALS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
Chester Oil Company,	Chester.
C. W. Burkhart,	Shoemakerville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Werner & Son,	Emporium.
C. E. Lenhart,	Latrobe.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
S. W. Morrison,	Oxford.
Capt. A. Goldsmith,	Quakertown.
J. L. Morrison,	Sharon.
Wm. A. Engel,	Shenandoah.
Wm. Schrock,	Somerset.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.

Displayman.	*Station.*
Signal Office,	Pittsburgh.
E. H. Baker,	Williamsport.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
E. S. Chase,	Eagles Mere.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
Armstrong & Brownell,	Smethport.
J. E. Forsythe,	Butler.
James H. Fones,	Tionesta.
Wister, Hacker & Savage,	Germantown.
W. J. Thompson & Co.,	Clifton Heights.
Steward M. Dreher,	Stroudsburg.
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
Hartford P. Brown,	Rochester.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.